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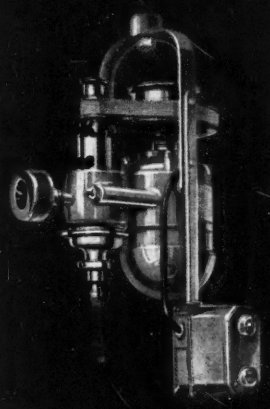

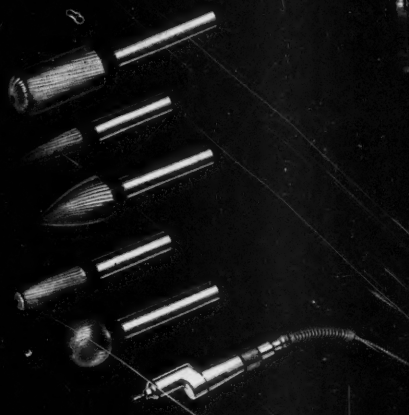

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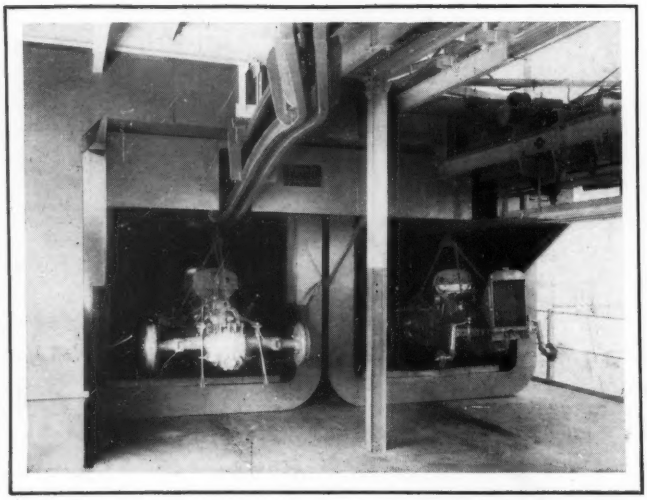
## INDUSTRIAL EQUIPMENT



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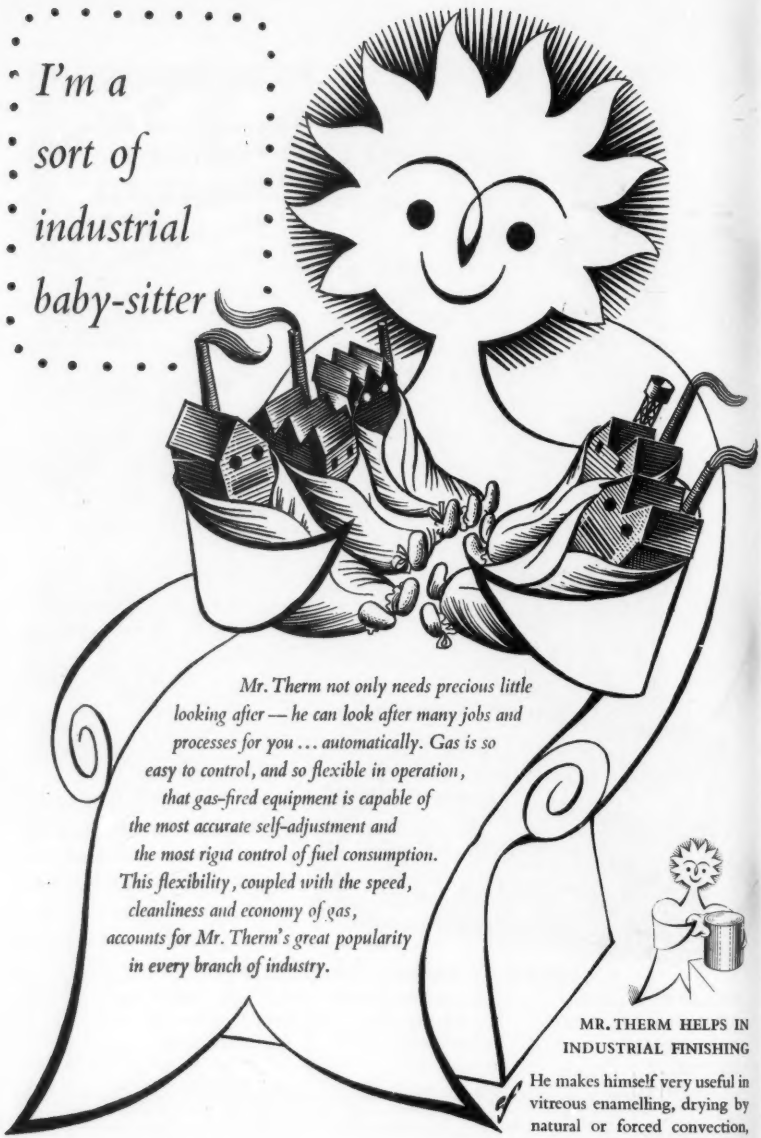

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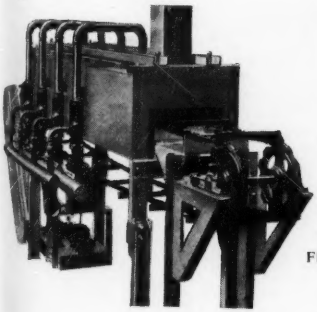

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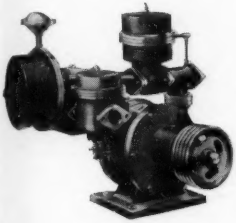

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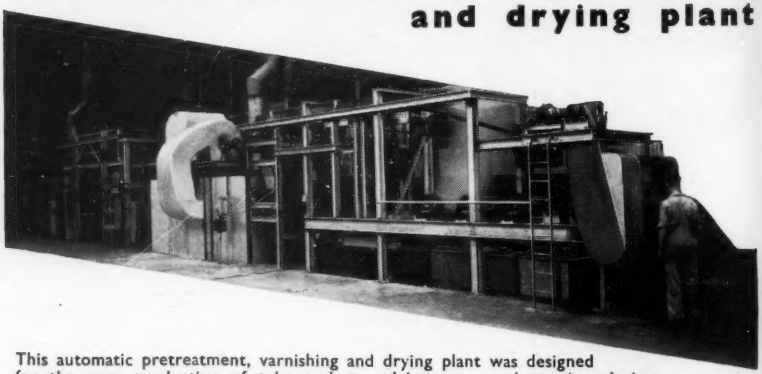

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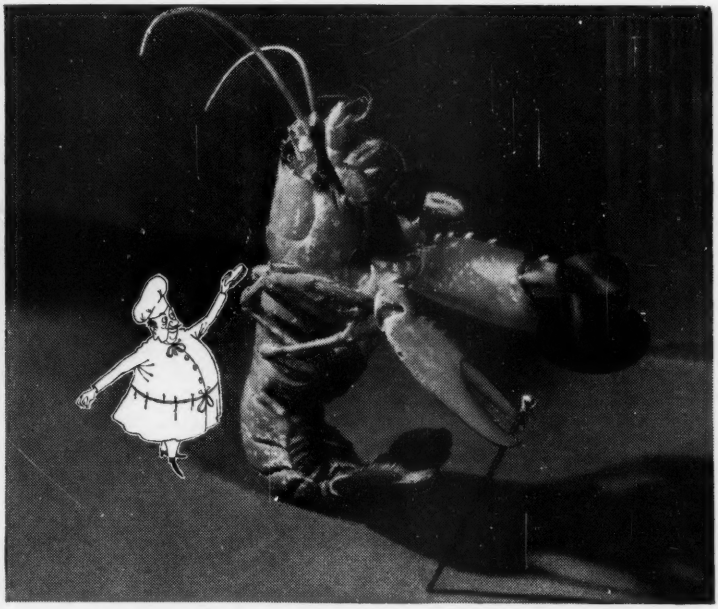

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Right: Fully automatic Rotary table polishing machine.

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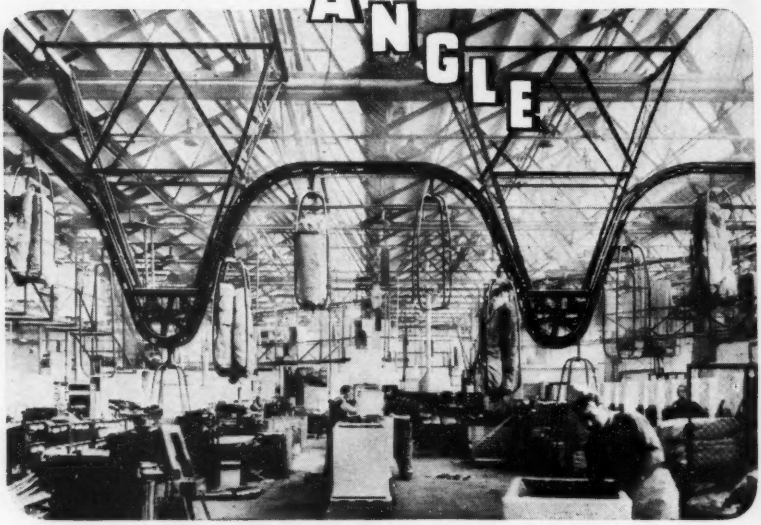

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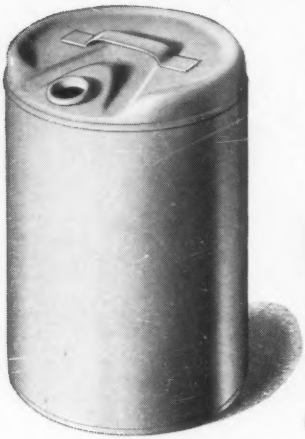

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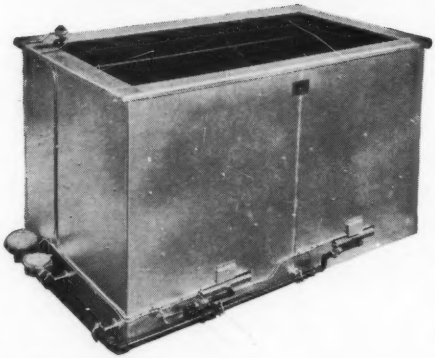

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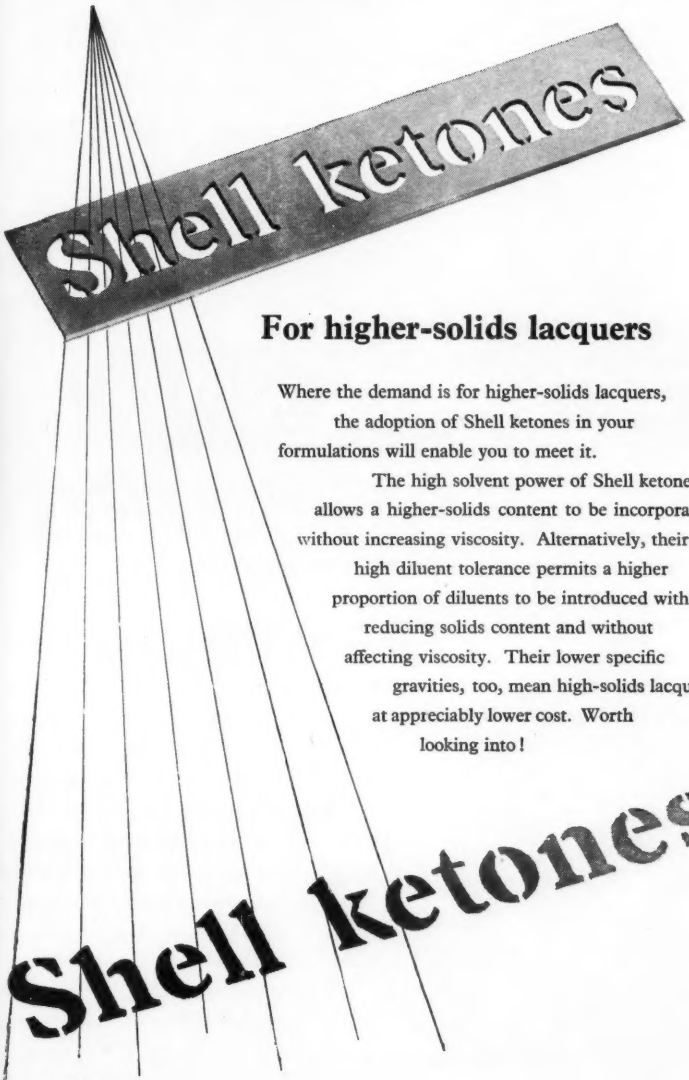


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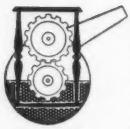

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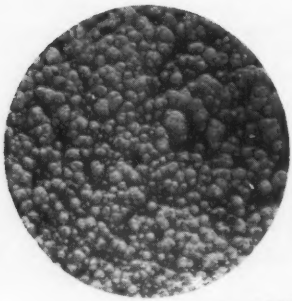

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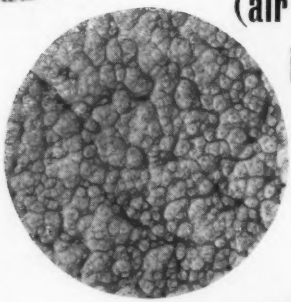

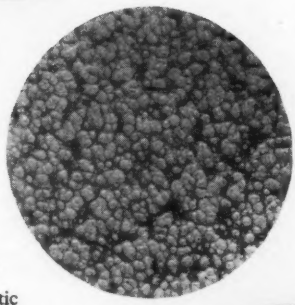

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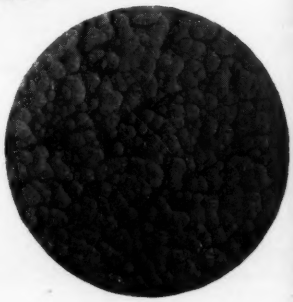

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## MARCH 1953

**FEATURE ARTICLES** *Page*

NICKEL RELAXATIONS—A BLOW TO COMPLACENCY 545

HIGH VACUUM METALLISING OF METALS AND PLASTICS ... ... ... ... ... ... 546

ALUMINIUM AND BRONZE PAINTS ... ... ... 562

ELECTRICAL MEASUREMENT OF CORROSION RATE... 568

COMMENT BY "ARGUS" ... ... ... ... 572

HOW TO CHOOSE MEASURE AND SPECIFY COLOUR 588

**MISCELLANEOUS**

FURNITURE EXHIBITION ... ... ... ... 567

YELLOW LEAD ... ... ... ... ... 571

FINISHING OF COPPER ALLOYS ... ... ... 576

FINISHING PLASTICS ... ... ... ... ... 578

AMERICAN FINISHING DEVELOPMENTS ... ... 580

NAMES IN THE NEWS ... ... ... ... 596

ADVERTISERS' INDEX ... ... ... ... 599

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Industrial Finishing

VOL. 5 MARCH, 1953 NO. 57

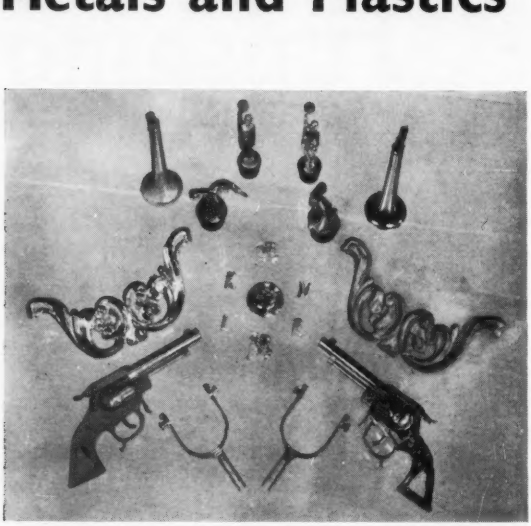
# NICKEL RELAXATIONS—A BLOW TO COMPLACENCY

THE easement in the Board of Trade's Nickel Control Orders which was announced last month, and mentioned on page 586, will be welcomed by all trade platers, especially those who do a considerable amount of work for the motor trade. We cannot help feeling, however, that it will prove to be a not unmixed blessing to the motor manufacturer himself. It has been very comforting to be able to say to the irate owner whose plating is pock-marked with rust spots after a few months of service "Yes old man, we know it's not as good as we would like to give you but it's the nickel shortage, you know." It was also very comforting to know that the customer would swallow the story. We are not by any means convinced, however, that nickel shortage and B.O.T. and M.O.S. restrictions are really the root cause of all this poor quality chromium. When all is said and done, cars of the years 1946 to 1950 had plating which, on the average, was much below the best standard, and that was before the nickel shortage and its accompanying controls had really come into being.

The reason we did not hear much about this was the fact that, prior to 1951, the manufacturer could afford to be a bit "high hat" about it as he could sell his cars as fast as he could produce them. The sellers' market is now a thing of the past and it will be interesting to see what happens next. Will we have a revival of the pre-war quality plate or will another excuse be found for the rash of rust spots?

Turning to the other side of this question of controls, it has always appeared to us to be the case that the regulations have been openly ignored by some sections of the plating trade and strictly observed by others. It would be interesting to know how many firms have "got away with it" and how many conscientious and careful platers have been left at a disadvantage. We cannot recall a single instance of a plater being prosecuted for non-compliance (no doubt there have been a few cases) and licences now appear to be granted quite readily, in many cases almost without question. All this seems to point to the regulations being continued for the sake of bureaucratic satisfaction long after the need for their existence has gone. The Nickel Control Orders should be scrapped and their place taken by a Code of Practice which would be designed to save nickel without prejudice to the plated product.

# High Vacuum Metallising of Metals and Plastics



*A typical range of products of the type which lend themselves to the vacuum coating process*

**AN INDUSTRIAL FINISHING FACTUAL REPORT**

WHILE vacuum deposition and metal evaporation have been known in principle and as laboratory projects for at least fifty years, it is only in recent years that they have actually been adapted to serve an industrial purpose. With the advent of high vacuum pumps, efficient vacuum systems and the "know-how" of modern high vacuum techniques, however, the process has started to find a stable level of usage. Already there are two or three firms in this country who are supplying equipment for vacuum deposition, there are three or four up-to-date trade platers who have installed plant to carry out trade work and there is at least one firm who are doing vacuum deposition exclusively as a trade service.

Used in a small way, before the recent war, to make optical reflectors, the process has since come into its own as a commercial production method for depositing a brilliant coating on plastics, metals and glass. The new finishes give a rich appearance that the operator can vary within a wide range of colours, metals and surface effects.

For some purposes vacuum depositions can be used to replace costly and tedious electroplating processes; for other purposes it can be used when orthodox plating techniques are impossible, or, at least, impracticable. Moreover, in many cases, it opens the door to applications which have hitherto been considered uneconomical. Typical examples of this are the continuous coating of rolls of plastic or similar sheeting as they are wound and rewound, special surface

patterns such as wrinkle or hammer effects which would cost far too much and be too difficult to polish in the ordinary plating technique, and the metal coating of plastic and pottery articles which have, hitherto, been expensive to plate owing to the fact that they are non-conductors and have had to be treated by silver reduction or given a graphitised coating prior to plating.

Before describing, at any length, the latest developments in the field it will be as well, perhaps, if we describe the principles of the process for the benefit of those readers who may not be familiar with the subject. The process consists essentially of three steps as follows: (1) preparation, which consists of coating the workpiece with lacquer and baking this to give a hard, glossy undercoat on which to deposit the film. This may be compared with the polishing of the workpiece in normal electroplating. (2) evaporation and deposition of the metallised coating. This, again, is roughly equivalent to the pre-plating with copper or nickel of an orthodox electroplated workpiece. (3) coating with lacquer to protect the newly deposited film. This is the equivalent of final plating and buffing in the electroplated job. It will be appreciated from the foregoing that the effect is to build up a sandwich of the evaporated metal between two layers of lacquer something after the fashion of Fig. 1.

Taking these three steps in their correct sequence, let us deal first with the lacquer undercoating. The undercoating is usually baked alkyd resin and its purpose is threefold: (a) It fills in and seals the microscopic pores of the surface and eliminates surface irregularities which would be exaggerated by the optical effect of the bright film. In this respect it replaces the more expensive and sometimes less effective hand polishing operation in the preparation of surfaces for electroplating. (b) It seals off, in the case of plastics, the occluded gases from the surface of the workpiece. These gases would adversely affect the adhesion of the deposit, in fact, the phenomenon of outgassing is one of the biggest difficulties in the metallising of plastics. (c) It eliminates the risk of galvanic action between the coating and the base metal in the case of deposits on dissimilar metal products.

Selection of a suitable undercoat material is a matter for some thought; the following are a few of the points that must be borne in mind when considering the composition characteristics:

1. It must possess good adhesion characteristics for both metal and plastics, for adhesion is a vital factor in the metallised film.
2. Its volatile content must be strictly controlled to prevent the migration of plasticisers to the surface where they may cause trouble through outgassing at later date.
3. It must dry with a hard, high gloss finish, to ensure that, when the film is deposited and the surface faithfully reproduced, it will possess a satisfactory shine or lustre.
4. It must be compatible with the top coat, with the deposited metal, and with the base metal so as to prevent any interaction which might have the effect of destroying lustre or continuity of film.

Prior to undercoating, the workpieces are, of course, cleaned in the conventional manner. They need not be "chemically clean" as for plating but the minimum requirement is degreasing and removal of all volatile film.

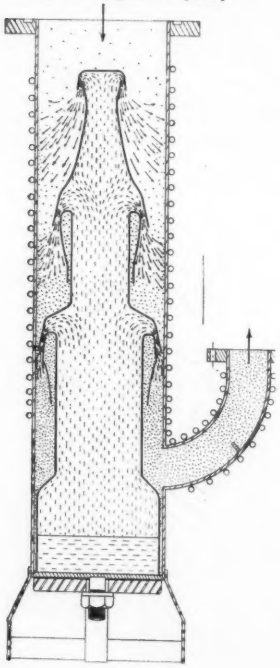
The actual application of the undercoat may be by almost any of the known commercial techniques, dipping and spraying are the most commonly employed but, later in this article, we shall describe the most recent developments. The basic requirement is that a hard, glossy film be obtained with the minimum of volatiles and with the maximum "spreadability" to fill in the minor surface irregularities. This film is baked and is then ready to receive the metallised coating.

*Fig.* 1. *Cross-section of workpiece*

The vacuum deposition process is basically a system of evaporation and condensation in which a metal, usually aluminium (but it can be almost any other metal) is raised to its boiling point in an evacuated chamber. The degree of vacuum reached is in the region of $\frac{1}{1{,}520{,}000}$ of one atmosphere pressure. In such a chamber there is practically no air and the metal boils off in vapour form. The vapour, unimpeded by air, travels in straight lines from the point of evaporation until it strikes some cooler object on which it can condense and, when enough has condensed to build up a film several millionths of an inch in thickness, a visible metallic coating is obtained. This coating has all the characteristics of the true metal, including its electrical properties and appearance and is firmly attached to the undercoating of the workpiece.

The exceptionally high vacuum required for the process is obtained from a combination of mechanical pumps, oil diffusion and oil ejector pumps. A diagrammatic representation of an oil diffusion pump is given in Fig. 2. The layout diagram at Fig. 3 is reproduced to show the valving and interconnections in a typical complete system. This is a typical small jobbing plant made in this country by W. E. Edwards Ltd., of Sydenham. The layout given at Fig 4 is of a large 48 in. coating plant built in the U.S.A. As will be seen, the basic principles are similar in each case, the difference is one of size only. The small plant uses a 9 in. oil diffusion pump and a rotary mechanical pump. The larger plant uses two oil diffusion pumps, three mechanical pumps and one booster pump to evacuate the large 48 in. chamber.

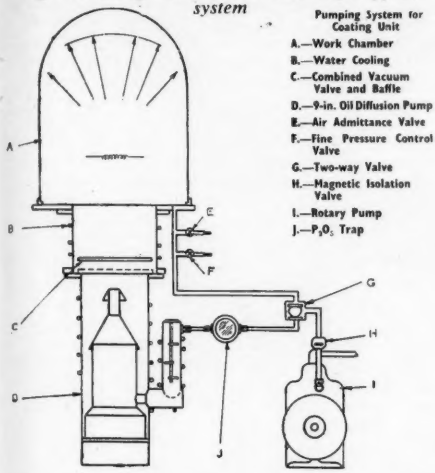
*Fig. 2. Diagrammatic Representation of oil diffusion pump*



It is the oil diffusion pump which has really made the vacuum deposition process a practical proposition. Formerly, pumps capable of producing such a vacuum had low capacities and the evacuation of any but the smallest volumes demanded painstaking care and considerable time; today's diffusion pumps, however, can evacuate chambers large enough to hold many thousands of small articles in a matter of minutes. The working principle of the oil diffusion pump is as follows: electric heaters boil a specially processed low vapour pressure oil in the base of a cylindrical chamber to provide the vapour streams seen emerging from the three cone-shaped skirts in Fig. 2. These vapour streams are discharged downwards at great velocity, they strike the cool sides of the water-cooled casing and condense, then they trickle down to the bottom to be vaporised again and repeat the cycle.

The gas molecules spread by their random motion, from the chamber and connecting pipes, into the upper half of the pump chamber which is open to the system. Here they are entrained by the vapour spray and carried downwards with the vapour to be expelled from the casing via the sidearm by the mechanical backing pump. The diffusion pumps cannot discharge against atmospheric pressure, consequently they have to be backed up by the mechanical

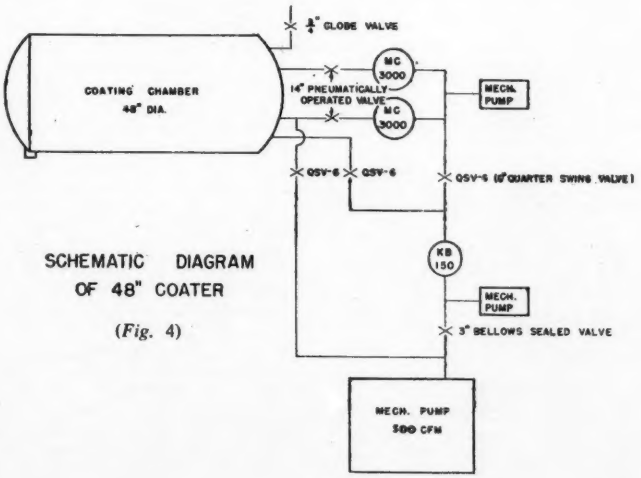
*Fig. 3. Valving and interconnections of a typical system*




pumps which collect and remove the air molecules concentrated by the diffusion pumps.

In vacuum work, pressure is measured in microns; one micron being ·001 mm. of mercury. Normal sea level atmospheric pressure is approximately 760 mm. of mercury. The mechanical pump is used to lower the pressure in the chamber from normal atmosphere (about 760,000 microns) to about 200 microns. The mechanical and diffusion pumps are valved in and out of the system as required to effect the necessary degree of evacuation.

The pumping sequence varies with individual plants but, as a typical example, the 48 in. machine shown in Fig. 4 may be quoted. In this machine there are three distinct and separate routes from the mechanical pump into the chamber. These three routes enable choice to be made of the best pumping combination in the range where it operates most efficiently. Route No. 1 is 500 cfm. mechanical pump to the chamber via a 6 in. vacuum valve. This route is used for "roughing," the initial pumping down of the chamber from atmospheric pressure to about 350 microns. At this point the 6 in. valve is closed and No. 2 route through the K.B. booster pump is used This is continued until the pressure is reduced to the region of about 15 microns. It will be seen that the booster pump is used to fill the gap between the point at which the large mechanical pump loses its pumping efficiency and the point at which the




SCHEMATIC DIAGRAM OF 48" COATER

(*Fig.* 4)

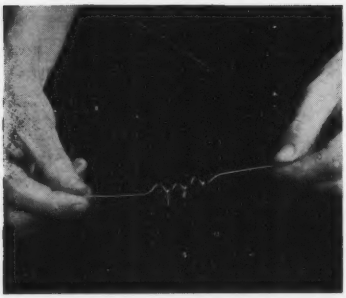


*Fig. 5. Filament with its loops in position ready for fixing in chamber*

diffusion pumps get into their stride.

No. 3 route is the final one; from the mechanical pump, through the booster pump and then through the two diffusion pumps into the chamber. When studying Fig. 4 it must be borne in mind that the two smaller pumps at the left are merely to "hold" the suction and maintain the efficiency of the diffusion and booster pumps. The third and last route can deal with pressures from the 15-20 micron range down to the ½ micron at which the process operates.

It is absolutely essential that the pressure in the chamber be maintained at less than 1 micron, otherwise dark and unsatisfactory coatings result. For this purpose accurate gauges such as Pirani or thermocouple types which work on the thermal conductivity principle in the range of 1 mm. Hg. to 1 micron and the iconisation type from 1 micron to $1 \times 10^{6}$ mm. Hg. are used. The Pirani gauges indicate the progress of the "rough" pumping down to about the level at which the diffusion pump starts to operate and the ionisation gauges show progress from there down to the final coating vacuum.

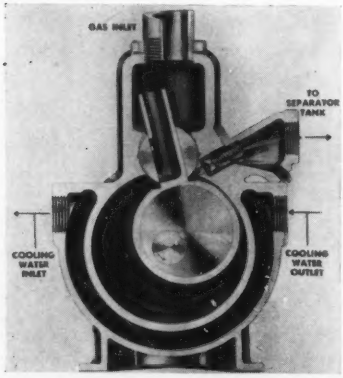
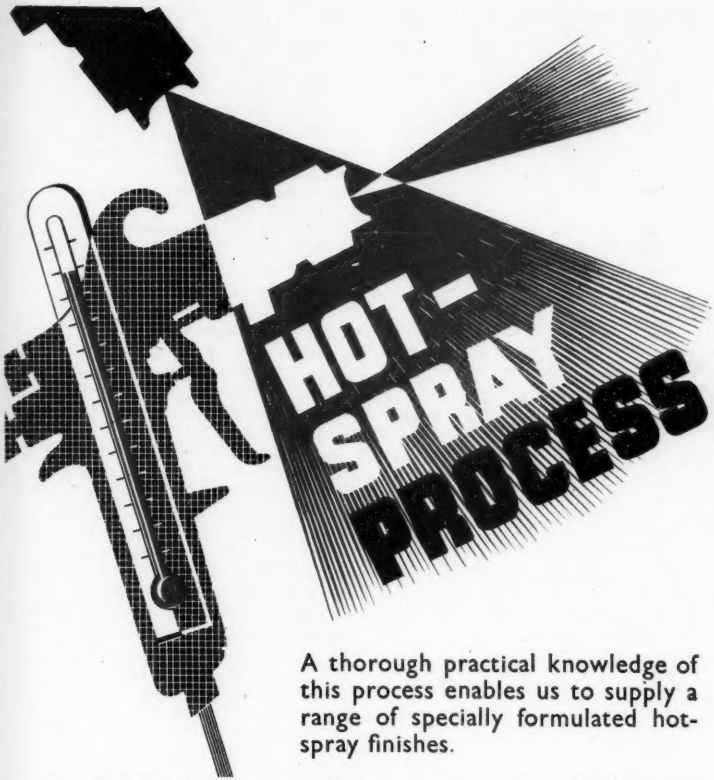



*Fig. 6. Sectional view of a typical mechanical pump as used for high vacuum*

Having reached the desired vacuum, the actual evaporation now takes place. Evaporation is usually done from a series of electrically heated tungsten filaments each consisting of a coil of tungsten wire about 10 in. long and by ·040 in. dia. wound helically into a coil about ⅜ in. dia. and 3 in. long. On each loop of the filament is hung a "hairpin" of aluminium wire. This combination of aluminium and tungsten is employed mainly because the aluminium has the property of wetting tungsten when melted, this simplifies the coating procedure as, otherwise, the metal would have to be evaporated from a small crucible or trough. The aluminium simply flows over the tungsten filament and adheres to it, enabling the vapour to emanate from a longer source than the central point of a crucible.

Usually the current supply to the filament is controlled by a variable transformer. In a production system the film thickness is controlled by adjusting both the current and the length of time for evaporation. The evaporation is effected by switching on the current to a degree which causes dull red heat. This is he'd for about 30 sec. to drive off any volatile matter, then it is increased to white heat and, at this heat, the metal vapour is given off and coating takes place. Fig. 5 shows a typical tungsten filament with its aluminium loops hanging in position.

Most metals can be evaporated in the vacuum chamber but, naturally, the lower the melting points the easier the process. Alloys cannot be worked yet because of the different points at which the constituent metals distil off, but research is proceeding on this at the present time. Of all the commercially available metals,

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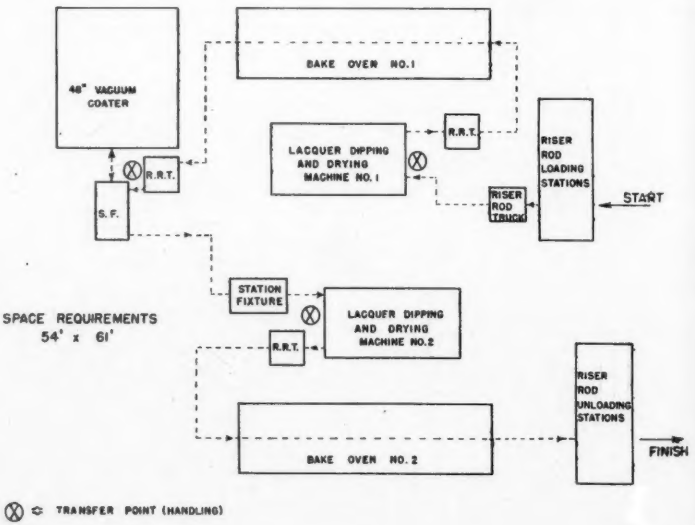
*Above, Fig. 7, work-carrying device with wire clips and a load of work in position*

*Below, Fig. 8, layout diagram of complete processing department as described in this article*

aluminium has, so far, shown the best return and is most used.

We now come to the last stage, the top coating of the deposited film to protect it from wear, to impart colour or to change its shade. The normal requirement is a plain water white transparent lacquer to protect the product from service abuse and abrasion. The requirements of the top coating are established by the service expected of the finished product rather than by any condition inherent in the process. If the top coat were to cause any reaction or swelling by contact with the underlying preplate lacquer, the adhesion and service life would be affected, thus one of the principal points is that the top coat must be formulated to be compatible with all the undercoats known to be in general use.

As aluminium, the most commonly used metal, is reflective throughout the entire visible spectrum, it is possible to achieve some wonderful metallic effects ranging through shades of gold and copper to almost any known metal, merely by dye-tinting the top coat lacquer. In order to permit the user to take full advantage of this, the top coat must be compatible



with all of the commercially used dyes. The question of residual volatility, so important with the undercoat, is not important in top coat materials provided that ageing of the top coat does not effect the undercoat and distort the metallic film.

In certain cases, when it is not subject to abrasion or risk of scratching such as in the case of headlamp reflectors, or other objects which will not be handled in use, it is possible to dispense with the top coat altogether and, if aluminium has been the evaporated metal, there will be no corrosion or subsequent tarnishing of the film. It must always be remembered, however, that the film is only of the order of a few millionths of an inch thick and is easily rubbed off, consequently every effort should be made to provide protection for it.

The most important operations in the preparation of workpieces for metallising are jigging and the application of the lacquer undercoat. Whilst much will depend on the variable factors of the job, such as the size of the workpiece, the quantity to be processed, the nature of the base material, etc., the real secrets of success will almost invariably lie in the careful planning and layout of the jigs and lacquering equipment. The following description of a complete production system for coating plastic products is based on information supplied by Applied Engineering Associates Ltd., U.S.A. and the American Kodak Co. who are responsible for its installation in an American factory, it serves as a good example of a carefully integrated system.

The system is based on the use of a work-carrying device in the form of a riser rod. This is a square steel rod with slots on opposite sides in which fit clips to hold the workpiece, Fig. 7. The arrangement of the work on the rod is a matter of some importance so as to prevent trouble from re-entrant angles in the dipping operation and consequent accumulation of lacquer. This riser rod, with its clips and workpieces makes the journey through all the stages of the process from loading of plastic work to unloading of metallised product.

Referring now to the layout diagram, Fig. 8, and the photograph of the dipping machine, Fig. 9, it will be seen that the operator loads riser rods on to the conveyor of the dipping machine which carries them into and out of the lacquer bath. The rate of immersion and withdrawal again is important as this is the controlling factor in the production of a clear coating of lacquer free from runs and tears. Leaving the dipping tank of the dipping machine, the work now passes through an oven tunnel section where a draught of heated air effects flash-off and preliminary drying of the film. This having been completed, the parts can now be processed through the remainder of the plant independent of atmospheric conditions, dust in the air, humidity, etc. As the conveyor returns the workpieces, they are reloaded on to the riser rod trucks to pass on to the bake oven.

Arrived at the bake oven, the riser rod trucks are pushed, by hand, into the inside of the oven where drying and final setting of the lacquers is completed. The baking operation should be under conditions of carefully controlled temperature and air circulation. In the oven illustrated in Fig. 10 this is accomplished by standard temperature recorder-controllers, and high-capacity fans re-circulating the air through a special heat transfer chamber. Internal ducting supplies high velocity air to all areas of the oven. The setting of the undercoat as judged by normal standards is not satisfactory for high vacuum processing. Retentions of volatiles, which may not be physically evident by examination under atmospheric conditions, may adversely affect the deposition of the metal in high vacuum. In addition to this, the retention of volatiles may introduce interference during the subsequent overcoat deposition.

The establishment of a minimum drying time and temperature for each coating material is essential to the process. In the specific design shown a more than adequate drying capacity is allowed with consideration of the production requirements of the total system. Over capacity for drying time up to 1¾ hr. for both undercoat and overcoat is feasible with the single oven installation.

After undercoat baking, the riser rods are removed from the truck and transferred into a station-holding fixture (see Fig. 11). The station-

holding fixture is the mechanism that carries the rotating stations on which a sizeable number of riser rods are loaded. A typical fixture would consist of from six to nine rotating stations. Each station is capable of carrying up to twelve riser rods.

The station spins on its own axis and the rotating parts are linked together by a chain drive and sprockets. Rotation of the riser rod by the turning of the static, exposes all sides of the workpiece to the central vapour flow which comes from the evaporating assembly fixed in the centre.

This assembly consists of four parallel copper bars arranged on a square so that tungsten filaments can be attached easily in a spiral pattern over the length of the bars (see Fig. 12). Current is passed through the filaments, generating sufficient heat to volatilize the particular metal which has been attached to the filament.

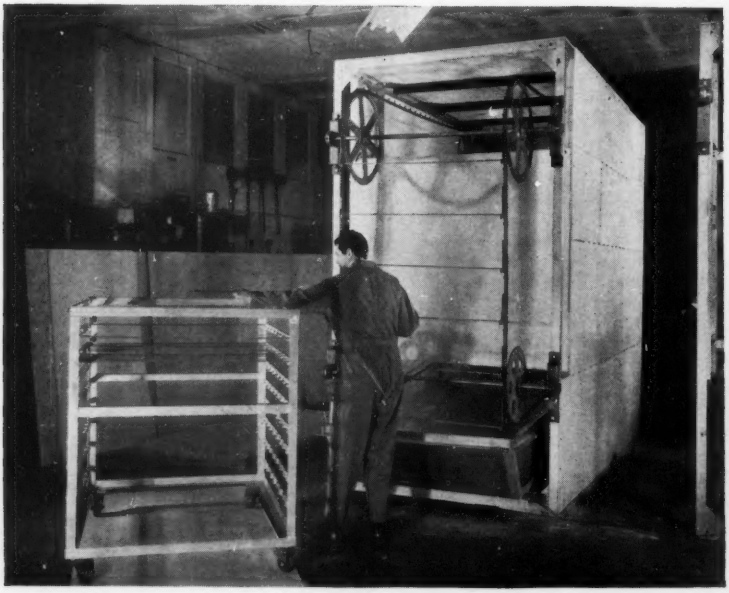
The station-holding fixture is slid into the chamber by means of a roller track and, once inside, the station holding fixture drive shaft engages with a drive mechanism projecting from the inside end of the vacuum chamber wall. The evaporating assembly is connected up to electrical supply connections inside the chamber and, after closing and locking the door, the pumping cycle commences.

Metal evaporation from the evaporating sources is begun when the pressure reaches 0·5 microns. Station rotation takes place prior to the evaporation and continues for a short interval afterwards. Air is then admitted to the chamber and the chamber door closed.

The station-holding fixture is now pulled off on to the trolley and the entire assembly is wheeled over to the second automatic dipping machine. Here the operator removes the riser-rod holding the metallised work and loads the units on to the chain conveyor. The dipping machine applies the protective topcoat from the bath.

When the station-holding fixture is

*Fig. 9. Riser rod trolley and conveyorised dipping machine—rate of withdrawal is considerable*



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unloaded, the filaments are reloaded with metal, or replaced if they have burned out. The whole assembly is then wheeled over to the first baking oven for reloading to start over again.

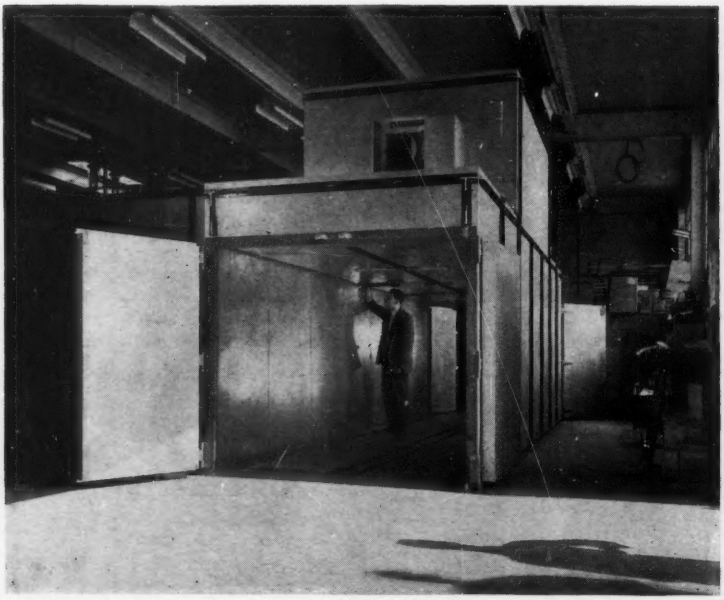
The operator of the second dipping machine removes the riser rod with the topcoated work, loads on a riser-rod truck, and transfers the truck to the baking oven. After baking, the finished work is removed from the riser-rods. The stripped riser-rods are then transferred to the assembly table where the initial operations start again.

The plant described above would require about 3,500 sq. ft. and operating costs will vary according to the size or complexity of the job, but the figures on page 558 will enable readers to form an opinion of the costs by applying knowledge of local prices to the requirements noted.

The production capacity of all high vacuum metallising plants is gauged by the productivity of the vacuum chamber itself, this is the fixed factor, other factors being capable of adjustment by adding more operators, speeding up the conveyors, providing better handling facilities and other methods well known to production engineers. The chamber, however, is the key to the productivity of the plant. Under the most favourable conditions, three cycles per hour can be obtained. The number of pieces that can be loaded into the vacuum chamber per cycle is a function of the volume occupied by the work-pieces. In the case of the 48 in. chamber which we have been using as a basis for the purpose of this article, the following are two typical cases.

Small plastic buttons have been processed using twelve riser-rods per station, with eight stations per holding fixture. This means 288 riser-rods per hour and, with forty buttons per rod, a total of 11,000 per hour can be handled. For this quantity, however, automatic loading and unloading would be desirable as an uneconomic number of operators would otherwise be required (actually about thirty). The case of the toy pistols shown in the photograph is

*Fig.* 10. *Bake oven into which the riser rod trucks are pushed*



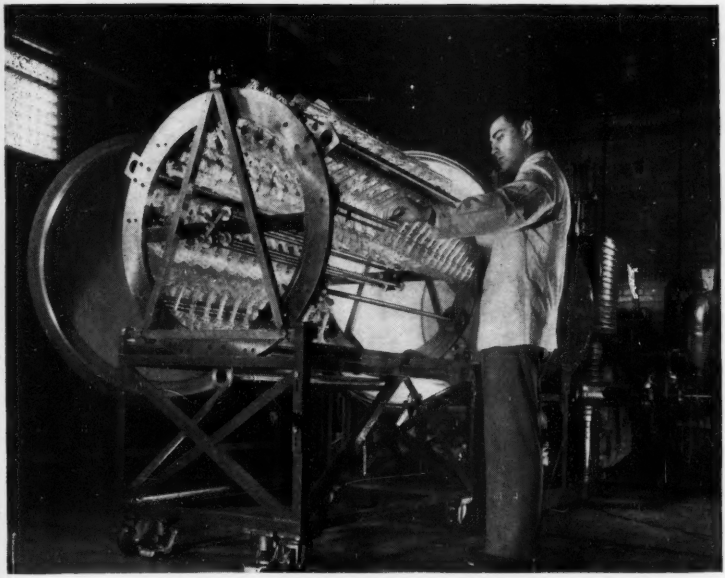
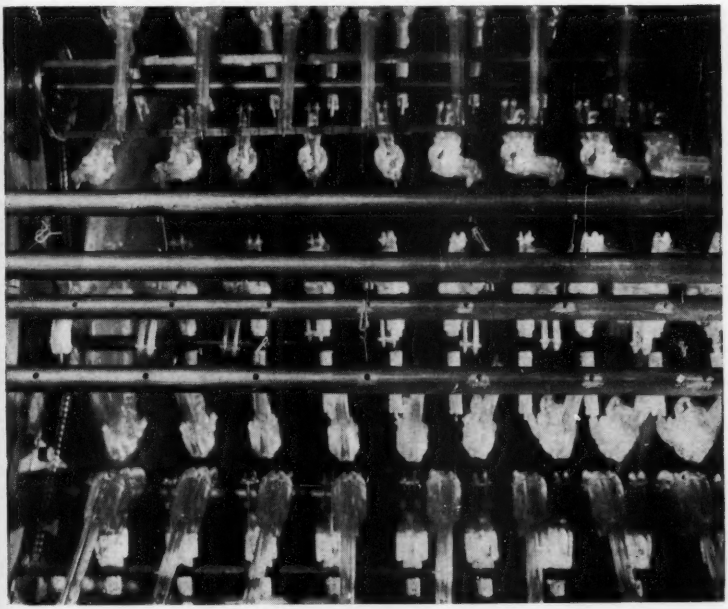


*Fig.* 11—*above—station-holding fixture*

*Fig.* 12—*below—assembly of bars, work and filaments*



## Operating Costs of 48" Plant

*Electrical power:* (*based on a* 48 *in. coating unit*)
Transformer
Mechanical pump
Backing pump
Diffusion pumps
Booster pump
Motor drive
Heaters for oil

} total approx. cost per hour: 18½ KW.

Ovens (Fan motor) } Circulating 7½ h.p. Exhauster 1 h.p. } Approx. cost per
Dipping machines } Conveyor motors ¾ h.p. } hour: 14 KW.

*Material:*

Lacquer for dipping machines ... Approx. 2 gal. per hr.
Tungsten filaments, consumable ... Approx. 50 ft. per hr.

*Miscellaneous items:*

Steam heat or gas for ovens ... Costs vary from plant to plant
Tooling costs, spring clips, wiring, etc. ... ... ... ...
Cost averages about 2d. but varies according to quantity and shapes

*Labour:*

Vacuum chamber: One operator.

Dipping machines: Two operators (one to each).

One relief or spare operator.

Total four, plus however many needed for loading and unloading riser-rods according to quantity, output, etc.

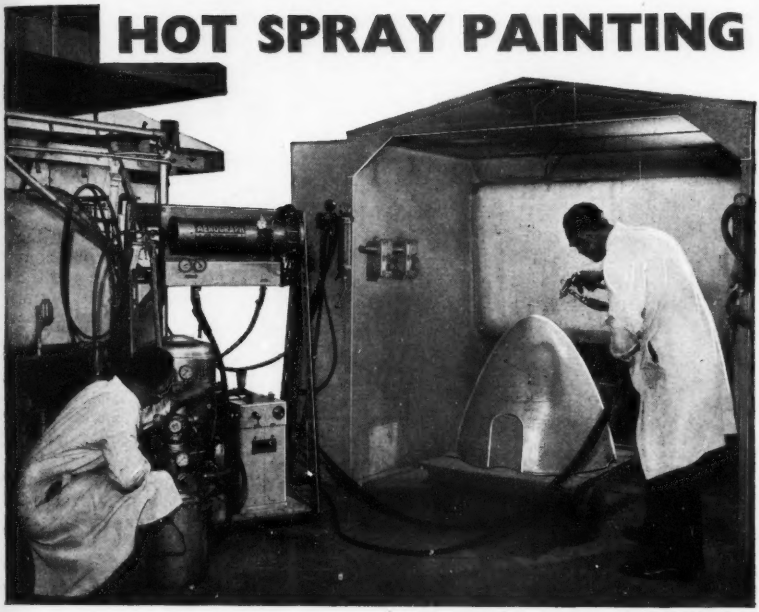
another good example. Each riser-rod carries thirteen pistols; there are three riser-rods to each station and eight stations in the holding fixture. Thus the total number of pistols coated is 39 × 8 × 3 which equals 936 per hour.

Economies can often be made in the consumption of lacquer by only coating the actual part which is to be metallised and an interesting development along these lines is the plant installed in one American factory which manufactures electric headlamps. In this particular plant the headlamp reflectors are mounted on a continuous moving conveyor with all the reflecting surfaces which are to be metallised facing in one direction. The conveyor carries them past a Ransburg electrostatic plant using the new type of spray head described recently in INDUSTRIAL FINISHING. This ensures that all the inner faces of the reflectors receive a coat of lacquer, but not the reverse surfaces. From the conveyor, the racked reflectors are transferred, still on their clips, to the riser-rods of the coating unit, after which they are dealt with in the same manner as the other work.

More recent applications of the vacuum coating method include metallising of flashlamp reflectors to save cost of plating, metallising of the reverse sides of plastic mouldings in transparent acetate material whereby certain parts show through as metal, giving the impression of metallic inserts. Quartz crystals used as frequency controls in electric oscillators are vacuum metallised to improve conductivity, yet the film is so thin that it does not affect vibration characteristics for which the crystal is precisely ground.

Gold leaf for blocking and stamping is now being made by combining a thin thermoplastic adhesive sheet with a layer of wax fixed to an acetate sheet which is vacuum metallised with the device to be transferred. The adhesive layer is placed against the work and a hot die, pressed on the acetate sheet, melts the wax, thus releasing the gold metal

# HOT SPRAY PAINTING



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The photograph shows a corner of the Demonstration Centre with operators hot-spraying synthetic enamels at the water-washed spray-booth. Three types of paint heaters are shown in the illustration. Take advantage of this "know-how" and let us help you to *control* your finish.

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pattern which, when the acetate sheet is lifted, is left as a perfect impression. The cost is very low, for the simple reason that a cubic inch of gold will coat 330,000 square inches of surface.

One of the latest developments, not yet being applied in this country to the best of our knowledge, is the practice of coating one or both sides of a continuous roll of material. The principle is shown in diagrammatic form in Fig. 13 and a typical plant layout drawing is shown at Fig. 14.

In this system the material can be cloth, paper, fibrous film or plastic material such as acetate or p.v.c. sheeting. In fact, one use for the process is the manufacture of heat reflective cloth for arctic wear to reduce loss of body heat without adding to the bulk or weight of the garment, yet still permitting the cloth to "breathe." Metallising of paper films reduces moisture vapour transmission so that the material is rendered more suitable for use as moisture proof packing.

An additional step in the coating of film material is the degassing stage. In batch work the chamber can be exhausted and, once this has been done, it will hold its vacuum despite a small amount of outgassing from the workpiece. In the case of roll material, however, the continued exposure of fresh surfaces as the roll unwinds means that outgassing goes on all the time the film is being unwound and this is sufficient to destroy all chance of depositing a successful film. In order to overcome this trouble a vacuum treating machine (A) in Fig. 14, is introduced and the purpose of this machine is to de-gas the continuous roll before it goes into the coating machine (B) Fig. 14.

At station (A) the roll is unwound and rewound several times by means of motors controlled by photo-electric reversing until sufficient gas is removed to ensure satisfactory processing in the vacuum chamber. Station (B) is a coating unit with a capacity of 1,500 ft. of 20 in. wide material, and it will coat it with aluminium at a rate of at least 20 ft. per min. It will require approx. 15 min. to reach coating vacuum, and allowing for loading and unloading, the complete cycle will be about 1½ hr. per roll, of 1,500 ft.

*Fig.* 13. *Principle of coating roll material*

Different methods are used for the evaporation of the metal from the filament as the process has to be continued for a considerable time and the simple tungsten filament would not have a sufficiently long life. The usual method is to make troughs or trays of the tungsten sheet into which the metal to be evaporated is placed. This method ensures that a large supply of vaporising metal is available which will last throughout the coating of the roll. (C) in Fig. 14 is the continuous application and baking unit for the protective topcoating. Starting at the left, the film passes first through a roller coater, then into a tunnel oven where it is dried, then, emerging from the oven, it is re-rolled.

The operating costs of this plant are, of course, fairly high by comparison with the plants described earlier, nevertheless they show considerable savings over any other known method of metallising film material. The biggest factor is the high electrical coat, this is the region of 40 KW. hours on the de-gasser and about 120 KW. hours on the coater for a 1,500-ft. roll. Lacquer consumption on the roller coater and baking tunnel have also to be taken into account, also, the metal which is evaporated and the metal of which the crucible is made. This latter may cost as much as £2 10s. per sheet.

Maintenance of the vacuum metallising plant is comparatively simple, being confined mainly to normal mechanical upkeep of the pumps and electrical equipment. In this connection it must be mentioned that the diffusion pump oil should never be exposed to atmospheric pressure when hot, because the hot oil decomposes at atmospheric pressure. If air is admitted to the system when the diffusion pumps are in operation and the oil is decomposed it is

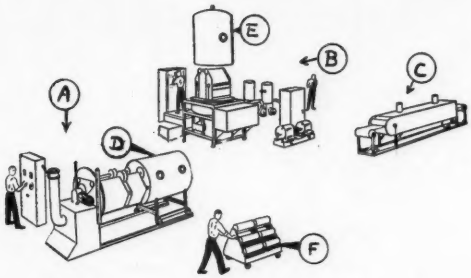


*Fig. 14.*

*A—Degassing station*
*B—Coating station*
*C—Continuous lacquering unit*
*D—Degassing chamber*
*E—Dome of coating chamber*
*F—Transfer of rolls from station to station*

necessary to take down the diffusion pumps, clean out the cracked oil and replace it with new oil.

It is good practice to include a variable resistor or auto-transformer in the heating circuit of the diffusion pumps. The input of the heat needed to produce maximum pumping speed in the diffusion pumps will vary with the fore pressure maintained by the mechanical pump, and the temperature and pressure of the water going through the cooling jackets, and occasional adjustment will be needed to keep the unit operating at full efficiency. Scale and rust accumulating in the water jackets of the pumps should be removed periodically to insure uniform cooling.

Another maintenance job is the removal of "overdeposit" from the walls and ends of the vacuum chamber. Some of the latest American plants have detachable liners in the chamber which greatly facilitates this operation. In plants not equipped with these liners the cleaning of the chamber is best carried out by washing with hot caustic solution until the aluminium either flakes off or dissolves completely, rinsing thoroughly with water and then drying by rinsing with acetone and allowing the acetone to dry. If the aluminium is allowed to build up it absorbs gases and water vapour which are slowly liberated while the chamber is being pumped down, significantly lengthening the pumping time. During evaporation the heat of the incandescent coils drives off more gases, causing a rise in pressure in the chamber during coating and resulting in a black or brown discoloration on the coating.

Another good idea adopted in some American plants is to fix a thin transparent plastic sheet in a frame in front of the observation window; when metallised this is removed and a fresh one inserted, the metallised film being removed from the first by dipping in a mild caustic solution.

Equipment and technique in vacuum deposition have developed to a point where the process can open new fields for the manufacturer and the finishing shop. Modern larger type machines are now able to treat workpieces as large as radio cabinets or as small as tiny plastic buttons; coatings are now being applied to glass ceramics and plastics at a cost which compares favourably with any process formerly used. Details of processers and suppliers are given in the panel on this page.

## VACUUM DEPOSITION SUPPLIES AND SERVICES

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**PROCESSERS:**

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Great Cambridge Road,
Enfield, Middlesex.

V.M.C. LTD.,
Croydon, Surrey.

Figs, 2, and 4 to 12 inclusive reproduced by courtesy of Applied Engineering Associates Ltd., Brooklyn, N.Y.

# Aluminium and Bronze Paints

By E. JOHNSON

THERE is no gainsaying the fact that metallic paints and lacquers are popular today. In addition to the usual bronze powders; silver, copper, gold, antique bronze, etc., the metal in most demand is aluminium, either as a straight pigment or for use in polychromatic and hammer finishes, etc. Yet; seventy or so years ago bronze finishes were commercially unknown. It is generally believed that Bessemer, of steel fame, started the manufacture of copper powders about that time. Since then processes have improved; the field has been extended and now metallic finishes of almost any colour are available. But, for some reason, the original title of "bronze," whatever the colour, still persists.

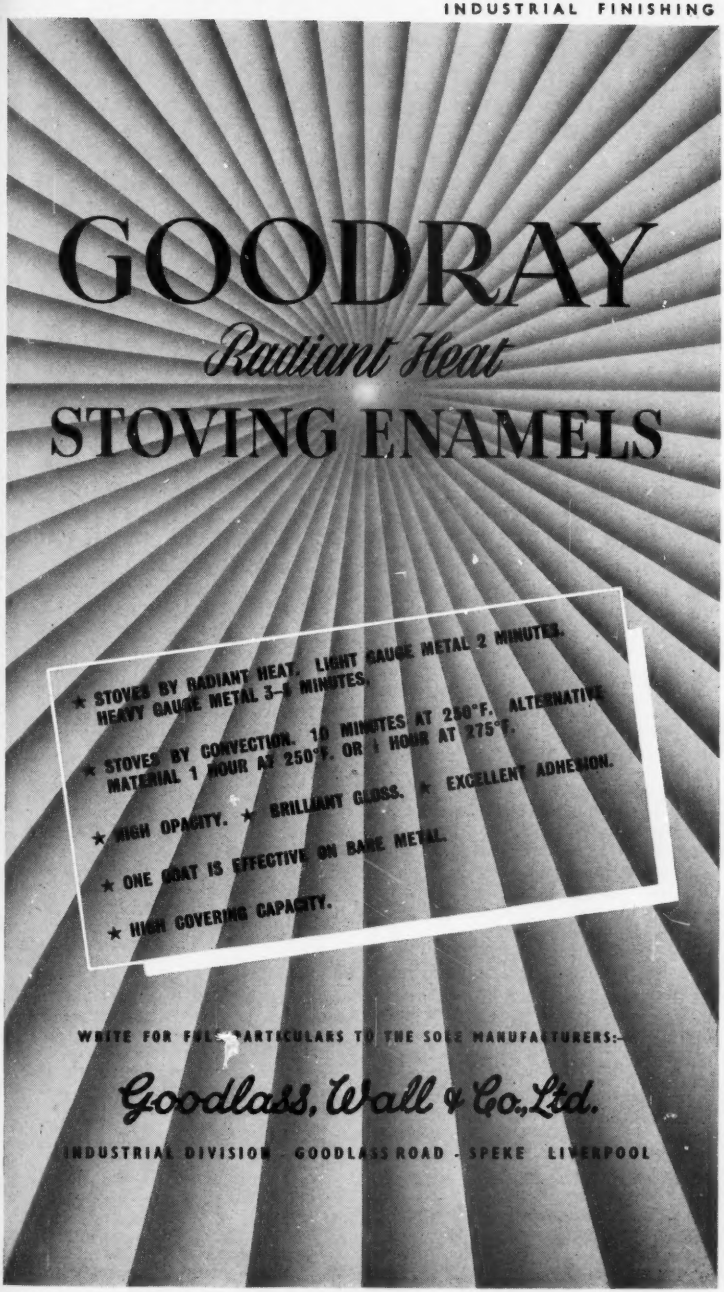
Of the metals, aluminium is mostly used and in recent years the powder form obtained by stamping thin aluminium foil into minute flakes has almost entirely been replaced by a paste product. This is not, as some people imagine, the same type of powder moistened with spirit. For the production of paste, hot compressed air is blown through molten aluminium and the atomised powder is collected and screened. The next step in the process consists of reducing and burnishing the powder in a steel-ball mill with white spirit and using stearic acid as a lubricant which also assists the leafing properties of the flakes. Filtering under pressure and the addition of more white spirit to reduce the paste to correct consistency, results in the finished product. This brief mention covers the process in general and methods of adjustment are involved to control the various grades.

The popularity of aluminium as a pigment is mainly due to its leafing formation. This in effect means that aluminium flakes in a suitable medium form a film which is comparable with a carpet of fallen leaves which overlap each other and are several layers in depth.

Although the aluminium content of paste is only in the region of 60 to 70 per cent. of the powder type, weight for weight, it can be used in approximately the same proportion and a better finish can be obtained because of its more even leafing and ease of mixibility. Whilst the finer grades, such as super-lining, may lose a little in relative leafing value in comparison with the standard grade consisting of larger flakes, the covering power is greater, but of course the paint film is weaker. The fine grades are mostly used in printing inks and in the majority of cases the standard product is fine enough for average paint pigmentation. In addition, a non-leafing type is available for use in primers and undercoats, and a fine grade which is particularly suitable for the manufacture of polychromatics.

For the benefit of those who stock aluminium pastes or powders and make up their paint as required, I would like to remind them that there are two important things to observe. The first is that strict fire precautions must be taken and that sand or soil should be used as an extinguisher—not water. Secondly, moisture must be kept away as when water comes in contact with aluminium, hydrogen is released which may easily start a fire and also build up sufficient pressure inside a container to burst it. Cool and dry storage are therefore of paramount importance.

The indiscriminate use of varnish as a medium or vehicle for aluminium paints will not do. The leafing effect depends on the ability of the medium to float the aluminium. A varnish of high acid value is more likely to produce a quick reaction if affected by moisture and will impair the leafing qualities and also cause the paint to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gell if stored for a lengthy period.

Mixing enough for immediate needs and the use of a medium which is supplied specifically for the purpose by a reputable manufacturer, is by far the safer method and better leafing and brilliance will be obtained. Using 2½ lb. per gal. on industrial work, such as steel, etc., good opacity and a coverage of about 70 sq. yards per gal. may be expected.

Aluminium paint is particularly useful on account of its light reflectivity and outside durability. The leafing qualities protect the underlying medium from the destructive effect of ultra-violet rays; it does not discolour in a sulphur-laden atmosphere and it is highly resistant to acid fumes. However, it cannot be recommended where alkaline conditions are likely to be encountered. Surfaces that "bleed" can be sealed with one or two coats, and pale colours may then be applied over it in safety. For heat resistant finishes, aluminium paint is most suitable. Even under conditions where the medium will eventually burn off, the aluminium will adhere firmly to the surface.

Bronze powders such as copper and gold, etc., vary in weight for bulk ratio. They all leaf, though not as efficiently as aluminium, and owing to the difference in specific gravity, a higher ratio of pigment to medium than that of aluminium is necessary. If the paint is to be mixed in the finishing shop some experiments with various concentrations will be required and for this purpose scales should always be used. However, bronzes are not suitable for dipping or flow-coating purposes and spray application is the best means of obtaining a smooth appearance and good leafing.

A roughish finish may be attributed to the use of coarse grades of powder; or too high a proportion of powder; or, in the case of ready-mixed paint; gelling and the formation of metallic clots due to prolonged storage and/or unsuitable medium. Bronzes tend to tarnish quickly and should be protected by a coat of clear varnish or lacquer. As far as heat resistance is concerned many bronzes will discolour if subjected to prolonged exposure to temperatures of 300° F. or over. Some of the dyed metallics are fugitive and often show signs of failure at 200° F., whereas polychromatic finishes, in a suitable heat-resistant medium, will keep their colour until the "spoiling" point of the medium is reached. In the case of heat-resistant low bake synthetics as supplied as bronzing medium for use on domestic heating equipment, this "spoiling" point can be said to be about 300°-320° F., which is well above the normal temperature reached on the framework of well constructed appliances.

In conclusion I would add that there are many paste forms of bronze which are much easier to handle than powder and possess similar advantages to aluminium paste. As the majority of these contain blown castor oil, a slightly longer drying time must be expected. If used in stoving medium the difference will not be noticeable.

---

## COMPETITION IN THE PAINT TRADE

THE growing intensity of competition in the paint, oil and allied fields was mentioned by speakers at the annual dinner of the Paint and Oil Section of Glasgow Chamber of Commerce. The solution offered by T. W. Oman, prominent member of the trade in the city and the past President of the Chamber was simple. Like the hens, the trade must adopt the policy: "The less they get the more they scratch." He told young men that none of them had ever experienced competitive trading; they all leaned on each other, on trade associations and on similar props. "You are all slumping along on crutches," he said expressively. The older men in the industry—many of whom he named—had been self maintained, self reliant, self sustained. They thought out the answers to their own problems and they survived. They were originals; they did not worry about the giant firms but traded on a basis of human being trading with human being. He thought they had a lesson for today although he also warned that no matter how hard one worked one could never expect 100 per cent. success.

The Chairman of the Section, D. J. Boyd, made a plea for the smaller family firm which he thought had an added incentive to give service, if only to carry on the good work of those who went before.

The President of the Chamber, Mr. T. G. Robinson, O.B.E., made the point that British industry deserved fuller

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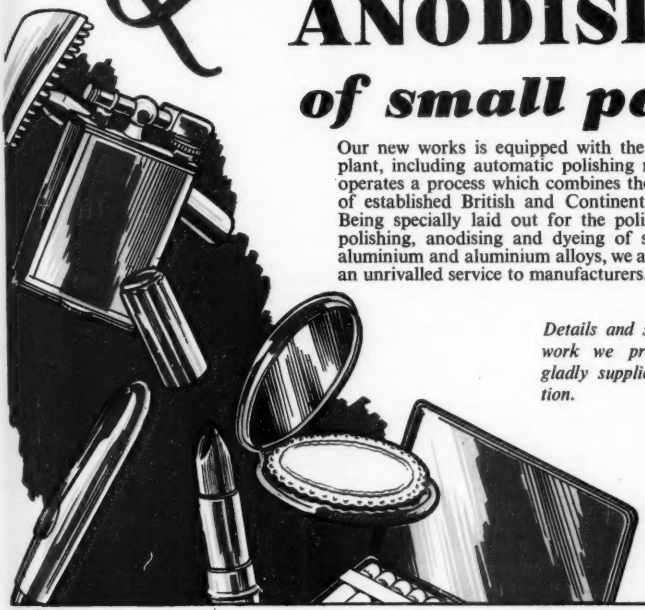

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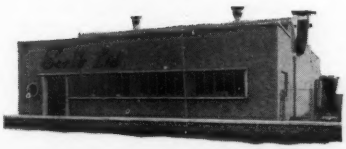

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support from the Government if the admitted inventive and trading genius were to be allowed to function. Industry required the finest machinery and tools available and there was need for diversion of the money which had been pouring into the Government coffers to purposes which would assist advancement of trade.

J. W. Cole, President of the National Paint Federation replied for "Our Guests" and John Fraser toasted "The Chair."

## CANNING QUARTERLY NEWS

THE February issue of the C.Q.N. will, in all probability, be recalled in the future as the "Sir Ernest Canning issue," as it marks a break in the long association of Sir Ernest as active head of the company. The issue reports fully the various staff changes that have taken place during recent months. It also contains photographs of the new directorate. Other features include an illustration of the gold-plated handle of the new Claerwen dam being operated by Her Majesty the Queen, a report of the Lord Mayor of Birmingham's visit to the works, news about the Canning Staff activities, and a report on the performance of a member of the London Staff at a Royal Command Performance.

## SPRAY SILVERING

FOLLOWING the article on the above subject which appeared in our January issue, we are advised by Earle Products Ltd., of Percy Street, Tottenham Court Road, London, W.1, that they have recently set up a factory for the operation of this process. The factory has now overcome its teething troubles and is in a position to handle about 800 gross of articles per week.

They claim that their process can be used on all materials except textiles and gives a durable metal finish in natural colours. It is particularly useful for applying a full mirror finish on plastics, ceramics and many other "difficult" materials. Typical examples are lead alloy and plastics model coronation coaches and china and glass figures.

For certain types of competitive work, the process has advantages over the vacuum deposition process in that the film can withstand considerably more service abuse and abrasion than the vacuum deposited film and the relative costs will usually stand comparison.

## CROCELLISING?

WE are informed by Croda Ltd., of Snaith, Goole, Yorks, that they have recently set up a special department for carrying out application of Crocell strippable coatings to customers' products at the customers' own works. It has been obvious to them for some time, they say, that some firms are not interested in purchasing strippable coatings of this type with the necessary tanks and equipment to carry out the process, but would be interested in having it done at their own works.

The project is tentative at the present time and its permanency will depend on the extent of the demand experienced when the service has been in operation for a little time. Enquiries should be addressed to the firm direct at the above address.

## USING THE B.S.S. FLOWCUP

WE are advised by the Industrial Finishing Division of British Paints Ltd., that they have available for distribution to *bona fide* users of industrial finishes, a number of plastic cups which comply with the appropriate B.S. Specification. The method of using these is outlined below and they are available from the head office of British Paints Ltd., at Newcastle-on-Tyne.

**Method of Use**

(a) Place the flow cup on a stand in a place free from draughts, and level by the use of a spirit level placed on the rim.

(b) Strain the sample into a clean container and adjust the temperature to meet the requirements specified in (c) below. This and the following operations should be carried out with minimum delay to avoid loss of solvent.

(c) With the orifice closed by the finger, fill the cup with the sample, until it just begins to overflow into the gallery, taking care to reduce the formation of air bubbles to the minimum. Free the surface from bubbles, if any are present.
Place thermometer bulb in the cup and check that the temperature is 25° C., plus or minus half a degree.

(d) Place a flat scraper on the rim of the cup and slowly draw it across until

the excess of the sample has flowed into the gallery.

(e) Place a suitable receiver under the cup.

(f) Remove the finger and simultaneously start a stopwatch or other timing mechanism.

(g) Watch the stream of liquid flowing from the orifice. At the first evidence of a break of the stream into droplets, stop the timing mechanism and record the time taken.

Assuming that the time taken is 55 sec., the viscosity of the paint would be described as—55 sec. British Standard flow cup type B.

The orifice size must also be quoted; namely—0·156 in. plus or minus 0·0005 in.

Although 25° C. is mentioned as the temperature at which viscosities should be tested, it will be found that some paint manufacturers have quoted figures taken at room temperature (65° F.).

It is important to note that such viscosities can be accurately checked if they are compared at 18·3° C. which is the centigrade equivalent for 65° F.

**Care of Cup**

(a) Clean the cup and its receiver immediately after use, employing a suitable solvent.

(b) Should the orifice become clogged with dried paint, soften with solvent and then clean with a soft brush or rag.

(c) The standard characteristics of the cup should be checked periodically. This may be done by observing under the conditions specified above, any change greater than plus or minus 5 per cent. in the flow times of a refined mineral oil, or other suitable liquid, kept as a standard.

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## FURNITURE FINISHES AT THE EXHIBITION

THE Furniture Exhibition which closed as this issue went to press, provided a good display of the art of the furniture finisher, also some excellent ideas which may be worth bearing in mind. I.C.I. Ltd. (Leathercloth Division) showed some types of plastics material including p.v.c. fabrics which can be classed as new materials in their own right as they do not in any way imitate leather.

The fairly recent marriage of plastics and wood, instead of the substitution of one for the other, was apparent in the number of tables of all kinds with plastics tops, sideboards with concealed plastics serving sections, and, of course, in kitchen furniture.

The increased scope in design allowed by the use of laminations bonded with synthetic resins was also evident. Many examples were seen of the useful and pleasing shapes and the strength and resilience of furniture made in this way.

A. Learner and Co. Ltd. (member of the Ault Wiborg Group) had a stand and showed many products for wood finishing. Their range of stains, fillers, base coats and lacquers were exhibited on many items of household furniture.

The Union Glue and Gelatine Co. Ltd. had a wide range of glues as well as their synthetic resin cements for hot or cold curing.

Hygena Cabinets Liverpool Ltd. showed a novel effect in their "Phantom oak" finish which enables kitchen furniture to take its place in the dining-room, if desired.

A fundamental change in the furniture trade since the last Exhibition is, of course, the end of the Utility scheme. In the Show will be found the first signs of the new freedom of design permitted under the "D" scheme without incurring heavy Purchase-tax, but it is too early yet for the full effects to be seen.

Broadly it can be said that the public will now be able to have refinements of design, such as additional shelves, drawers or purely decorative features, without having to pay Purchase-tax on the whole of the cost of the piece of furniture—Purchase-tax being levied only on the amount by which the cost exceeds the "D" figure. The new scheme does mean, however, that certain goods which were of the highest quality possible while still remaining within the Utility range now bear a small tax.

---

**Altones Ltd.,** specialists in the processing of aluminium, have recently closed down their Newhouse Industrial Estate factory which has been operating for some years past. The plant used to employ about 100 people when in full operation, but has decreased its staff considerably in recent months as the trade has been considerably decreased. Altones Ltd., carried out a great deal of experimental and prototype work on coloured and multicoloured processing of fabricated light metals, with particular reference to the costume jewellery, giftware, household ware and allied fields.

# ELECTRICAL MEASUREMENT OF CORROSION RATE

A RECENT laboratory study by the U.S. National Bureau of Standards proves for the first time that the rate of weight loss of a piece of steel corroding normally in soil can be measured electrically, without actually weighing the metal. Conducted by W. J. Schwerdtfeger and O. N. McDorman of the Bureau's corrosion laboratory, the study gives further evidence that the electrochemical theory of corrosion applies generally to soils. Although the new measurements were restricted to the laboratory, the success of the work suggests the possibility of valuable practical applications, such as determination of the corrosion rate of a tank or other underground structure without the need for visual inspection.

When iron and steel is exposed to the soil, local differences in electrical potential develop at the surface of the metal, resulting in the formation of numerous small corrosion cells. This means that electric currents flow through the soil from certain areas (anodes) to areas of less negative potential (cathodes), with accompanying discharge of hydrogen ions at the cathodes and loss of metal from the anodes. By Faraday's law, the rate of weight loss from corrosion is proportional to the current.

The Bureau-demonstrated measuring technique is based on a relation established by other investigators, who showed that the current in a corrosion cell can be expressed in terms of the values of anodically and cathodically (positively and negatively) applied direct current, from an external source, that will just reduce the cell current (corrosion current) to zero. The relation is

$$i_o = \frac{I_p I_q}{I_p + I_q}$$

where $I_o$ is the corrosion current, and $I_p$ and $I_q$ are, respectively, the cathodically and anodically applied currents required to reduce the corrosion current to zero. As increments of current are applied, the potential of the cell changes. When the measured potentials are plotted against the applied currents, a change in the slope of the curves usually marks the points ($I_p$ and $I_q$) at which the applied currents have reduced the local corrosion to zero.

The corrosion cells used by previous investigators in confirming the equation experimentally contained separated anodes and cathodes, so that $I_p$ and $I_q$ could be directly measured and the corrosion currents computed there from compared with values obtained by direct measurements. However, when a single piece of metal is exposed to a corrosive medium, as in the present study, it is obviously impossible to measure these currents directly. Here the corrosion current, made up of innumerable small cell currents, must be determined indirectly, if at all, from changes in slope of the current-potential (polarisation) curves.

The present study demonstrates for the first time that the total corrosion current $i_o$—and thus the weight loss—of a single piece of metal normally corroding in soils, and presumably in other aqueous media, can be determined by the equation, from values of $I_p$ and $I_q$ obtained from the changes in slope of the cathodic and anodic polarisation curves.

In establishing the feasibility of the indirect measuring technique, weighed steel specimens, differentially aerated, were exposed at the Bureau to five corrosive soils for approximately two months. The soils ranged in reaction from very acid (*p*H 2·9) to very alkaline (*p*H 9·6). Because of the possibility of changes in rates of

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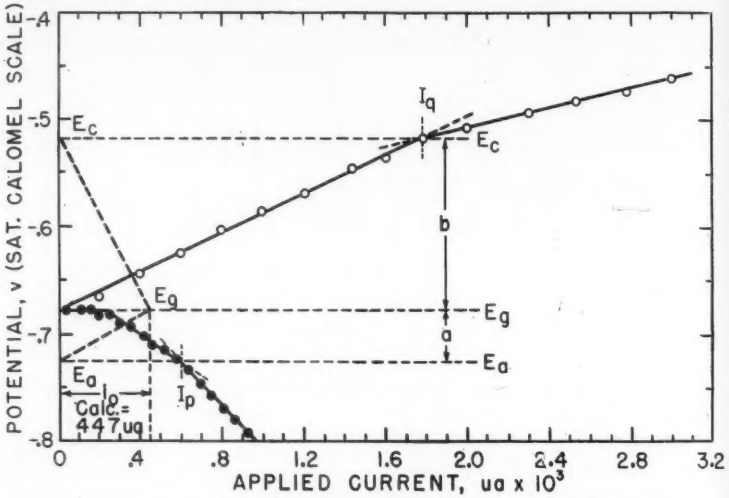
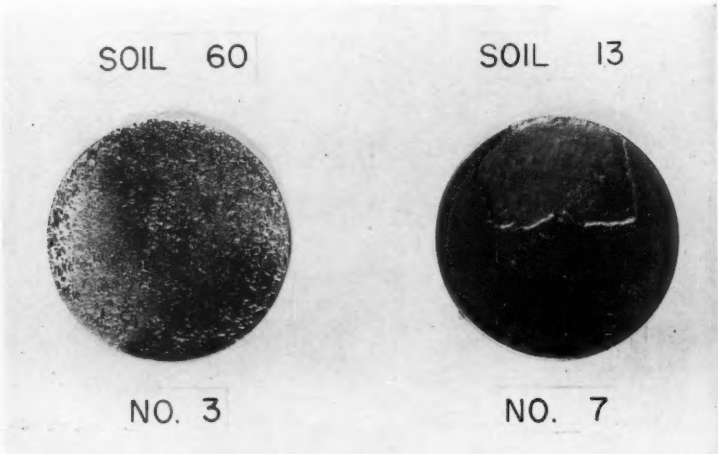



*Polarisation curves of a steel electrode exposed to a certain soil in the U.S. National Bureau of Standards investigation. The curves are typical of ferrous materials corroding in soils. Potentials were measured with an electronic interrupter in conjunction with a potentiometric circuit. Significant changes in slope of the curves occur at values of applied current $I_p$ and $I_q$. After the value of the corrosion current $i_o$ has been calculated from $I_p$ and $I_q$, the triangle connecting points $E_c$, $E_g$ and $E_a$ can be completed. The line $E_c$—$E_g$ then represents the hypothetical polarisation of all the cathodic elements, and the $E_a$—$E_g$ applies similarly to the anodic elements; these lines show whether the reaction is cathodically or anodically controlled. The current $I_p$ is the value required to prevent corrosion, commonly known as the current needed for cathodic protection. This current was found at the Bureau to bear a relatively fixed relation to the corrosion current $i_o$, so that the latter can be estimated from the former*




*Steel specimens exposed to soil corrosion for two months in the U.S. National Bureau of Standards corrosion laboratory. The specimen on the left was exposed to acid soil (pH 2·9), that on the right to alkaline soil (pH 9·5)*

corrosion during the two-month period, polarisation curves were obtained at intervals throughout the exposure period.

At the end of this period the specimens were removed from soils, cleaned and reweighed. Actual weight losses were compared with weight losses calculated indirectly by Faraday's law, using values of corrosion current ($i_o$) obtained from the equation on the basis of values of $I_p$ and $I_q$ indicated by changes of slope in the polarisation curves. The calculated values of weight loss differed on the average from the actual values by approximately 4 per cent.

This technique for indirect electrical measurement of corrosion rate appears to have possibilities for extensive application both in the laboratory and in the field. In laboratory determinations of the corrosion rate of certain materials, for instance, the weight loss resulting from corrosion might actually be exceeded by the cleaning error. The electrical method makes possible much more accurate comparisons of the corrodibilities of such materials.

For field determination of underground corrosion the electrical method, if it proves practicable in the field as well as the laboratory, would have several advantages in addition to obviating the need for excavating the underground object. Although in some soils ferrous metals corrode at a constant rate year after year, in other soils corrosion gradually slows down and in time may virtually cease.

Actual weighing or inspection of an object that has been buried for years will indicate how much total corrosion has occurred, but will not show how rapidly, if at all, it has been corroding just prior to inspection. The electrical method, on the other hand, measures the present corrosion rate, which is likely to be of greater practical interest than the history of past corrosion. Furthermore, the electrical method does not involve the removal of corrosion products, which often inhibit corrosion.

---

**The British Brush Manufacturers' Association** are holding their sixth annual conference at the Royal Beach Hotel, Southsea, on 26th, 27th and 28th May.

# YELLOW LEAD

FOR very many years, red lead has been recognised as an outstanding corrosion-inhibitor, although it has certain inherent disadvantages. Constant attempts have been made, therefore, to produce an alternative pigment with equally good rust-preventing qualities but which would overcome the drawbacks of red lead and be more economical in application.

Research in the Jenson and Nicholson Laboratories, backed by practical exposure tests in the U.K. and on the Continent, has resulted in the development of yellow lead, a new anti-corrosive primer, marketed under the trade-name "Ledomide."

The pigment of Ledomide is in the form of lemon-coloured micro-crystalline acicular particles, with a specific gravity of 6·1-6·3. In the dry film, the acicular or needle-like particles tend to interlock to give a "haystack" type of structure of high film strength.

Yellow Lead is actively anti-rusting. It reacts with acidic atmospheric contaminants ($CO_2$, $SO_2$, $H_2S$, $H_2SO_4$) and the acidic break-down products of linseed oil, transforming them into insoluble non-corrosive compounds.

Yellow lead has an alkaline passivating action, due to its amphoteric character and its tendency to form ammonia. Despite its high reactivity as regards lead soap formation, it shows very little thickening on storage. Only after lengthy periods is there any definite tendency to thicken. Even then, only mild thickening occurs which can be readily removed by stirring or thinning. Thus, any wastage through material becoming unfit for use is eliminated.

Another great advantage of Ledomide lies in its relatively low specific gravity and its voluminous form. It does not evaporate or settle and, therefore, remains fit for use for a long period.

Its covering power is in the region of 124 sq. yards per gal.

---

**J. H. Sankey and Sons Ltd.,** have been appointed sole distributors of the "Glopane" series of cold galvanizing and zinc rich paints for England, Wales and Northern Ireland. Henderson and Keay Ltd., of Glasgow still retain the Scottish sole distribution rights.

# Comment . . .

*by* **ARGUS**

AN excellent book entitled *The Industrial Finishing Year Book* is available, but the chapter dealing with bright nickel plating is indeed very much behind the times. A very large proportion of bright nickel plating in Britain is now carried out by the Gleamax process of W. Canning & Co. Ltd., or the Efco-Udylite process of the Electro-Chemical Engineering Co. Ltd.—and both these processes involving organic brightening agents are overlooked in this chapter. That steps are being taken to remedy this defect in 1954 is not of much help to the 1953 reader. However, it just goes to show that in the best regulated circles "clangers" are by no means uncommon.

Another publication from the Anglo-American Council on Productivity is entitled *Inspection in Industry*, and the team has made some suggestions—they include establishing a technical qualification for inspection —this seems to be the universal solution in these enlightening times. Whatever the subject there is always someone coming along wanting an Institution of this, or an Association of that; and already there are enough of these to fill a textbook with their names alone. The team also suggests that all production engineering courses should include a course on statistical methods applied to production inspection and experimentation. Already engineering courses have extended their scope to such an extent that an engineering graduate cannot hope to cover other than a smattering of its requirements. The team wants short, intensive, full-time courses in statistical engineering, whatever that might be—they suggest the unification of Government inspection procedure, and that the mass production industries should devote more attention to the mechanism of inspection.

Undoubtedly inspection is a very important cog in the production wheel, but it must be remembered that inspection only takes place after something to inspect has been made. If there is an intensification of effort and a complication of the inspection procedure this must surely detract from normal productivity to the disadvantage of productivity itself.

Finishing is a subject in which inspection is undoubtedly of extreme importance, but one regrets to say that the team did not bother to say much in respect of this.

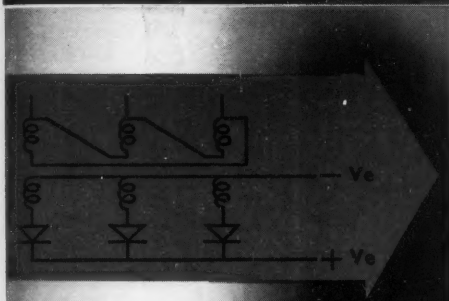
There is great danger in this tendency which prevails to ignore the difficult problems, of which finishing inspection is one, and concentrate upon the relatively easy problems of mass production of small parts where the mathematician can really go to town and produce the most complicated stories about quality control.

But it still does not get one very far if one has 100 per cent. inspection ability and 50 per cent. productivity. One reads in every report the recommendations of which this may be quoted as an example: "Inspection personnel should be chosen for their ability to earn confidence and respect."

Quite seriously, for "inspection personnel" one could write practically every other job in the production machine. This is absolutely platitudinous preaching with little tangible use at the end.

Incidentally, the two photographs on page 574 give some idea of the kind of problem brought about by floods—it shows the works of the British Domolac Co. Ltd. at Abbey Wood, in South East London, which were submerged for nearly three weeks. One gathers that essential supplies of materials were maintained during the whole time and what is more important that these deliveries were made possible because various friends of the Company in the trade helped to the maximum, which is indeed the highest commendation of that spirit

# RECTIFIERS FOR ELECTROPLATING



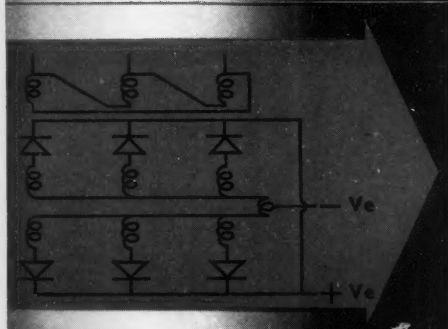

**NORMAL PLATING RECTIFIER**

OUTPUT 8 VOLTS 1000 AMPS

RIPPLE 18%

INPUT 400 VOLTS 3 PHASE

17·9 AMPS




**PATENT INNERCOOLED PLATING RECTIFIER**

OUTPUT 8 VOLTS 1000 AMPS

RIPPLE 4%

INPUT 400 VOLTS 3 PHASE

15·9 AMPS

—SO TO CONVERT THE HIGHEST PROPORTION OF AC MAINS (EVERY UNIT OF WHICH MUST BE PAID FOR) INTO A SMOOTH & CONSTANT DC SUPPLY FOR THE PLATING VATS SPECIFY ECC.

*Ask for Brochure B. 1365—"More Efficient Plating."*

ESTABLISHED 1882

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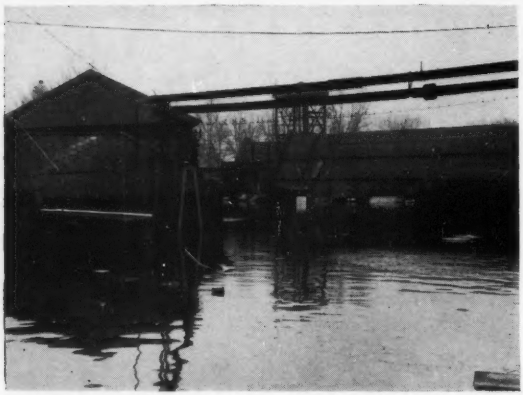
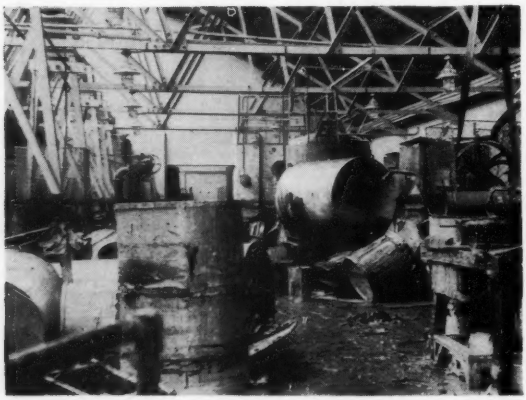
Head Office and Works: BUSHBURY ENGINEERING WORKS WOLVERHAMPTON ENGLAND

TELEPHONE WOLVERHAMPTON 21455 (2 LINES)

*Manufacturers of Rotating Electrical Machinery, Switch and Control Gear, Rectifiers and Transformers.*



*Water, water, everywhere! Scene in the factory yard of British Domolac Co. Ltd. at Abbey Wood, London, S.E.*



*Reminiscent of "blitz" days is the wrecked appearance of the interior. The water lifted tanks bodily from the ground and tore away piping*

of respect and co-operation which prevails in the finishing industry. It is an object lesson to the opponents of private manufacture.

It was no mean flood, for on the night of the 31st January/1st February there was between six and eight inches of water in the drive, and by 9.30 a.m. there was 3 ft. flooding, which meant that the factory had more or less to be abandoned. By noon the floods were between 5 and 9 ft. over the whole area. Yet by the end of February 60 per cent. of normal production had been restored because friends in the industry had agreed to produce in their own factories to British Domolac formulations, under the Company's technical supervision. Whilst competitors were making Domolac products the Royal Arsenal Co-operative Society provided office accommodation without charge, which is indeed a fine example of what can be done in face of an emergency.

Dr. S. Wernick, hon. secretary of the Institute of Metal Finishing, addressed the Avery Institute in Birmingham, on 5th March, in these words:

"It has been suggested in some quarters that the finish on post-war cars is inferior to that which was applied before the war. This contention is against all the facts. Important advances which were developed in the laboratory and

introduced in the factories just before the war produced superior finishes to those applied in the early 'thirties. This was indeed fortunate, as it enabled cars of the 1937-40 vintage to stand up so well since and compare favourably with American cars of the same period.

"Finishes on post-war cars, having regard to the high rate of production which was necessary to take advantage of export markets immediately after the war, and also the baneful restrictions on the supply of nickel with which the Industry has been faced, have been well up to standard. Manufacturers of car accessories have used every scientific advance and invested considerable capital in the most up-to-date plant, and British cars in consequence have little to fear in comparison with their American counterparts. Indeed, the Americans consider that we are inclined to over-finish cars by giving them what they call a 'jeweller's finish' rather than the 'kerb-side finish' which is favoured over there. There may be something in this contention.

"As regards the finish on car bodies, the Rotodip process, which is widely applied on many makes of car in this country and ensures the protection of the body on parts which are not seen as well as those which are visible, undoubtedly produces a superior finish to that applied by the spray processes commonly used in American car plants.

"We have no reason for complacency, and never has finishing been so important as it is today to keep our place in highly competitive world markets. On the other hand, we have much to be proud of in the advances in metal finishing practice which have been developed in this country.

"It is not fair that the metal finishing industry should be condemned because an occasional spot of rust is seen on a car. Often this is the result of the negligence of the owner of the vehicle."

Fair enough, dear Doctor, but a little birdie whispered sweetly to us that the sellers' market had closed and the "customer is once again right." The finishing industry must develop finishes for the car owner who regularly bashes his car bonnet with a cosh!

Seriously though, for the finishing industry to seek an excuse for its own inadequacy at the expense of its customers is a fatuity.

## I.V.E. WHITTLE SILVER MEDAL

THE fifth competition for the Whittie Silver Medal of the Institute of Vitreous Enamellers has been announced. The Whittle Foundation Competition, which, in addition to the Silver Medal, includes cash prizes, was formed in order to encourage junior chemists and other technicians in the enamelling industry to express their ideas in the form of a written paper. The subject of the fifth competition will be "One-coat White Enamels," and notes for the guidance of authors can be obtained from The Secretaries, John Gardom and Co., Ripley, nr. Derby.

The paper should be from 3,000 to 5,000 words, with the necessary illustrations, and must be written entirely by the competitor, although experimental work done by others can be referred to with due acknowledgment. Care must be taken to see that information given in the paper is not confidential, and competitors are advised to submit their papers to their company for approval before sending them in for consideration.

As mentioned, the competition is intended for junior staff, 30 years of age or under, but where a competitor has been on national service or away from the industry on war service of another kind, and this is stated in a covering letter, the time on such service will be subtracted from his actual age and taken into consideration by the Assessors. All papers must be submitted by 30th June, 1953.

## MR. H. SILMAN TO TAKE CHARGE OF NEW FORD RESEARCH SECTION

THE Ford Motor Co. Ltd. announce plans to establish a centre for advanced engineering research in Birmingham. This will supplement and extend the work being carried out at Dagenham. Mr. H. Silman, B.Sc., F.R.I.C., F.I.M., A.M.I.Chem.E., A.I.Mech.E., formerly of Joseph Lucas Industries Ltd., has been appointed research manager of the new department.

---

JENOLITE LTD. are now producing a greatly improved, much more powerful version of their successful alkaline paint stripper and degreaser (P.S. 5). Like its predecessor, the new stripper is supplied in powder form. For standard purposes it is mixed in the ratio of 1 lb. to 1 gal. of water heated to 95° C., and is used in a mild steel tank. The powder has gained a reputation for its unique properties of maximum efficiency with great economy.

# Finishing and Plating of Copper and Copper Alloys

## SOME INTERESTING REFERENCES AND FACTS

FOR some years the Copper Development Association has prepared and issued a six-monthly review of current technical literature dealing with copper and copper alloys. The most recent of these publications (issued January, 1953), contains a considerable number of references to papers and literature on the subject of finishing and plating and, in view of the current interest in this subject, we are reproducing this complete, together with the references so that interested readers can make further studies if they so desire.

Shortage of nickel has recently led to the development of alternative electrodeposited coatings, especially for use beneath chromium. Of these, white brass,[1] bronze[2] and a ternary alloy of copper, zinc and tin, seem to rank among the more promising, while a bright copper deposit from an acid solution can also be used with or without a flash of nickel beneath the chromium surface. Both Chadwick[3] and Miller[4] presented papers at the Summer Conference of the Institute of Metal Finishing on the electrodeposition of chromium directly upon copper and copper alloys.

In reviewing the intensive development work which has been carried out in America on periodic reverse current plating, Halls[5] mentions quite phenomenal mechanical properties which may be obtained for copper electrodeposited by this method. Based on statements by Jernstedt,[6,7] he quotes tensile strengths of up to 50 ton/sq. in. with elongations of about 9 per cent. and hardness values of the order of 220 diamond pyramid numbers. In the light of these figures, Jernstedt[7] himself comments that copper deposited by the PR process seems to be inherently different from any copper produced in the past. It is possible that the extraordinary mechanical properties claimed are connected with the use of addition agents (e.g., "WES-X") to the bath.

Though electrolytic polishing has won a firmly established place in the metallographic laboratory, and is already in use to a considerable extent for the commercial polishing of light metals and steels, the mechanism of the process has received comparatively little attention in the past. A careful experimental study of the phenomenon,[8] with special reference to smoothing efficiency in the electropolishing of copper in phosphoric acid, is therefore to be welcomed. It is stated that electropolishing should be possible in any solution in which the metal dissolves anodically, provided that complete control can be exercised over all other factors, and it would therefore appear that much of the time and effort directed in the past towards the development of special electrolytes, many of them quite complex, may have been been misapplied. The paper ends with several pages of practical recommendations which should certainly be studied by all who use the process.

An interesting development is the production of fine-mesh metal gauze by electrodeposition upon textile fabric, especially for refuelling funnels, where water is to be separated from petrol.[9,10] Both copper and nickel have been used for the purpose and tests for durability after intermittent immersion in sea water at room temperature and exposure to a moist atmosphere at 70° C., have given satisfactory results. The material has also passed tests for resistance to wear.

Electrodeposited copper is well known as a "stop-off" in the case-hardening of steel and normally gives excellent results for this purpose. Ruffle and Chawner,[11] however, report instances in which the effect of the copper in preventing access of the

carbon to the steel appeared to spread slightly beyond the confines of the plated area, thus leaving parts soft which should have been hardened. This mysterious phenomenon led to a great deal of trouble and occasionally held up production completely. After a most painstaking exploration of all the factors which could possibly, and even improbably, give rise to the effect, the authors traced it to the presence of small quantities of barium sulphide in the barium carbonate of the carburising compound, and indicate that the co-presence of hydrogen in the carburising box is necessary. They suggest that the apparent migration of copper may take place through the growth of copper sulphide or by diffusion of copper sulphide into a film of iron sulphide on the steel.

In the nitriding, as distinct from the carburising of steel, it is said that electrodeposited bronze containing 10 to 15 per cent. of tin has largely superseded tin plating as a "stop-off" medium.

Queries frequently arise concerning the cleaning and preservation of bronze statues; the subject is dealt with by Jack,[12] who gives detailed instructions for the treatment of new statues, periodic cleaning and the renovation of neglected statues.

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## MOND NICKEL FELLOWSHIPS

APPLICATIONS are now invited by the Mond Nickel Fellowship Committee for the award of the Mond Nickel Fellowships for 1953. The purpose of these Fellowships, as is probably well-known, is to enable selected applicants of British nationality and educated to University degree or equivalent standard to obtain additional training and wider experience in industrial establishments, at home or abroad; so that, if they are subsequently employed in executive or administrative positions in the British metallurgical industries, they will be better qualified to appreciate the technological significance of research and to apply its results.

There are no age limits, though awards will seldom be made to persons over 35 years of age. Each Fellowship will occupy one full working year. It is hoped to award five Fellowships each year of an approximate value of £900 to £1,200 each.

Applicants will be required to define the programme of training in respect of which they are applying for an award, as well as particulars of their education, qualifications and previous career. Full particulars and forms of application can be obtained from The Secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, S.W.1.

# FINISHING OF PLASTICS

**"The overall policy of American moulding companies is to eliminate hand finishing as far as possible, because of the labour costs involved . . . "**

THE Productivity Team Report on the Plastics Moulding Industry in the U.S.A., published last month, contains some interesting notes on American methods of finishing plastics. The team saw nothing revolutionary in the way of finishing, but some of the American methods are of possible interest to readers in this country and a summary of them is given here:

*Lettering*

Lettering on mouldings is accomplished by several methods already known in Britain, as follows:

1. Moulding sunken letter forms in the moulding, and filling these with paint by various means, removing the excess by hand wiping, or buffing;
2. Blocking by means of a hot punch, used in conjunction with a leaf process;
3. Offset printing.

Of these methods the first two are the most common, the third being used only where the moulding is not likely to receive much handling in service, as the lettering can be smudged or rubbed off fairly easily. In the paint methods, the paint may be applied to the moulding by hand brushing, by machine brushing, or by spraying, with or without masks. Excess is then removed by barreling with wood chips or balls, followed by lighter buffing, or in some cases by barreling only. This may also be done by wiping by hand while the paint is still wet, or by means of a rag soaked in thinners. An example quoted of work of this type observed in American factories, is an oven control knob.

This moulding has lettering moulded in on both top and sides, and is so shaped that removal of excess paint from a recess on the top would be most difficult. The procedure is to brush in paint by hand for the lettering on the centre of the top face, and then mask the recess and mount the assembly of moulding and mask on a horizontally revolving spigot. Two spray guns, one placed radially and the other at 45° to the horizontal are operated in sequence, the second gun following automatically after the first.

*Printed on Thermoplastic Mouldings*

Various conventional methods of printing on thermoplastic mouldings were seen, but in practically all cases multi-station rotating tables were in use. With these the operator had only to load the mouldings on to pegs or into recesses and the rest of the cycle was fully automatic. Offset printing with rubber stamps was also seen.

*Spray Painting*

This is used much more extensively in America than in Britain, and the methods adopted are interesting. A fixture seen quite frequently was an air-operated clamp with the mask fixed to the top, and the air cylinder underneath. The moulding to be sprayed was placed on a jig which was well below the mask and easy of access, and by operating a treadle valve the moulding was raised underneath the mask and clamped firmly during the spraying operation; release of the treadle returned the plunger to the bottom position. By using both hands a very high rate of output could be obtained.

*The Wheelabrator Tumblast*

This machine was originally developed for blast-cleaning metal products such as castings, forgings, etc., on a batch basis. Recently it has been applied to the removal of flash from plastics mouldings.

It consists essentially of a perforated rubber mat in the form of a belt covering the full width of the tumbling compartment. The belt passes over two rollers and the work is placed on the mat between the points at which it passes over them. These rollers rotate and drive the belt, thus tumbling the work. At right angles to the moving belt a stream of de-flashing medium is directed on to the work and breaks off flash from the edges and clears flash from holes. The de-flashing media in use for plastics are usually crushed apricot pips and crushed walnut shells.

These pass through the perforations in the mat, and are returned by way of a bucket elevator to the wheel which throws them on to the work. Variable capacities are available from one cubic foot upwards, and most large-scale compression moulders in America have installed one of the machines.

The Tumblast* is in use in Britain for its original purpose of de-flashing metal products. For use with plastics the following are of special importance:

1. Variable speed drive;
2. A load balanced to the capacity;
3. Suitable de-flashing media;
4. Steam feed into the hopper;
5. Reasonably thin flash.

** We should, perhaps, emphasise that the wheelabrator tumblast, despite the American use and the "novelty angle" publicity given to it by certain sections of the daily press, is by no means new to this country. R. J. Richardson and Sons Ltd., of Birmingham, have had them in operation for many years and have installed them in dozens of factories up and down this country, and they have been built into a good many conveyor systems.—Ed.*

## METAL PROCESSES LTD., COME OF AGE

IT was twenty-one years ago this May that Mr. W. J. Turner, M.I.Mech.E., present managing director of Metal Processes Ltd., founded the company to market the original "De-Ruster" process, for phosphating iron and steel. Since then many other metal treatment processes have been added to the firm's list, and the latest two, developed and marketed since the B.I.F. last year, are both new black finishes. Known as "Turbla" and "Brunette," they are identical in application to the present Mark II black, but the cost is said to be much lower. A new degreaser for the aircraft industry is also announced.

## HEAT TREATMENT PRACTICE

PRELIMINARY notice is given by B.I.S.R.A., of a conference on Heat Treatment Practice to be held on June 15th, 16th and 17th next, at Ashorne Hill, Leamington Spa. It is intended that there shall be papers and discussion on the heat treatment of engineering steels and large forgings and sections, surface treatments, isothermal heat treatment and temperature measurement and control.

The conference, which is being organised by the Metallurgy (General) Division of B.I.S.R.A., is expected to provide a meeting ground for engineers and steelmakers affected by these problems. Any persons wishing to attend should apply to Mr. A. M. Sage, B.I.S.R.A., 11 Park Lane, London, W.1.


INDUSTRIAL FINISHING

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# American Finishing Developments

A DIGEST OF THE ARTICLES DEALING WITH FINISHING PROCESSES, WHICH HAVE BEEN PUBLISH D IN U.S.A. TECHNICAL JOURNALS.

### Copper Content in White Brass or Copper Cyanide Plating Solutions Can Be Increased by Electrolytic Regeneration

It has become increasingly necessary to use copper and white brass instead of nickel and nickel chemicals in chromium plating for decorative purposes, because of the scarcity of nickel for civilian uses. However, copper cyanide must be added frequently to the white brass solution or the cyanide copper solution in order to maintain the copper concentration. A new method of introducing copper to the plating solution has recently been devised. This method involves use of an electrolytic regeneration cell. Operation can be intermittent or continuous.

In order to maintain a stable cyanide plating solution, it is necessary that the rate of metal plating out at the cathode be nearly equal to the rate of metal entering the solution at the anode. This will minimise the free cyanogen concentration.

The electrolytic concentration cell is an apparatus which will introduce copperions to the electrolyte at a rate that can be controlled to suit individual requirements. The cell is a rigidly constructed box of rubber-coated steel, 30 in. by 30 in. by 4 in. It has four windows or openings on each side, each containing approximately 100 sq. in. Wooden diaphragm panels fit tightly into these openings and make a perfect water seal. Cypress is very suitable for the diaphragms after being properly de-resinised. A cypress panel containing 100 sq. in. and $\frac{1}{8}$ in. thick will conduct approximately 75 amp. One cell has a capacity of approximately 500 to 600 amp. A disadvantage of cypress, however, is the effect of heat on it. For white brass solutions where the operating temperature is not in excess of 100° F., cypress has a reasonably long life. But for cyanide copper solutions where the temperature may be as high as 180° F., cypress will deteriorate in a short time. It is advisable to provide means of cooling the electrolyte in the regenerating tank to 120° F.

After the cell has been fitted with the wood panels, an electrolyte of 2 oz. per gal. of potassium hydroxide is placed in the solution-tight cell. The latter is then placed on the cathode rod of the plating tank. The wood diaphragm serves as a screen when the current is turned on. Hydrogen is evolved at the steel cathode within the cell. In order to raise the metal content to a given value, it is necessary to calculate the total metal required in terms of Faradays.

(*Plating, October,* 1952.)

### Experiments With One-coat Enamel on Steel Predict Low-cost Enamelled Ware

A one-coat white enamel finish for steel which would reduce the cost of serviceable enamelled ware and yet exhibit the physical and chemical properties normally associated with multi-coated ware, has long been of interest to enamellers. Recent experiments indicate that such a process may now be practicable.

Much credit for the success of the one-coat process to date, even with special steels, must be attributed to the high reflectivity of the titanium enamels used. These thinner coatings are greatly responsible for some of the excellent physical properties being obtained in one-coat ware.

The problem, as in most metal finishing, appears to resolve into three categories; the metal employed, the coating, and the treatment of the metal prior to coating. Perhaps the most important single factor is process control.

# FUEL ECONOMIST

EDITORIAL DIRECTOR: W. F. Coxon, M.Sc., Ph.D., F.R.I.C., F.I.M., M.Inst.F.

*fortnightly*

## EDITORIAL CONTENT

Primarily to encourage efficient fuel usage based on practical considerations.

***KEY POINTS***

★ High efficiency solid fuel appliances.

★ Adaptation as to existing houses.

★ Economy benefits of correct insulation.

★ Parliamentary reports.

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It was found that increasing the surface roughness improved the bonding properties. This could be achieved either by sandblasting or acid etching. Also used to aid surface roughness was the nickel flash. In addition to the acid etching and the nickel bath, an acid treatment after the nickel flash was used. The acid treatment does not, to any extent, attack the nickel coating, but does serve to etch the exposed "valley" of iron.

In order further to check the action of the acid treatment on the flashed coating, the acid-etched steel was given a cobalt flash. These specimens were then treated in hydrofluoric acid. This treatment further increased the bonding properties.

An enamel sufficiently fluid at enamel-firing temperatures is required for the rough porous surface of the nickel-flashed steel. It is necessary that the molten enamel flow into the pores and crevices of the metal surface, dissolve the surface oxides, allow gases from the metal and interface to pass through the coating, and then heal over these small areas where bubbles have disrupted the enamel surface. Thus, an enamel that normally matures in firing at 1,500° F. when fired on top of another enamel coat, will need an additional 50° or 60° F. when processed as a one-coat enamel. The higher temperature is necessary to effect a lower viscosity of the enamel.

(*Finish, September,* 1952.)

### Surface Finish of Instrument Parts Automatically Controlled

In order to obtain greater volume with production-line methods, together with uniform quality, The Foxboro Co., Foxboro, Massachusetts, has developed an automatic control system for the surface treatment of instrument parts. Formerly, the parts were immersed in Bonderite. The newly installed Spra-Bonderite unit is completely automatic and processes 22,000 parts in one 8-hr. shift. The parts are made from a variety of metals, including iron, steel, and aluminium. The standard finish is a very high quality infra-red baked lacquer, usually black, although a choice is available in several other colours.

The new surface treating equipment consists of a completely enclosed tunnel, 45 ft. long, 12 ft. high, and 6 ft. wide, which is divided into five sections: spray cleaning, rinsing, phosphate treating, clear water rinsing, and subsequent rinsing. As the parts pass through these separate stages on a continuous conveyor line, they are sprayed from every angle by the rinses and solutions, which are continuously recirculated. Hollow parts, which are difficult to spray, are conveyed on long carrier hooks which travel close to the bottom of the tunnel where they are subjected to a thorough internal spraying.

The flexible overhead conveyor consists of a wrought iron chain, approximately 450 ft. in length, driven on an overhead track by ¾ h.p. motor. Speed varies between 4 ft. and 12 ft. per min. Parts are completely finished in 30 min. Small items are hung on hangers or handled in baskets. The larger ones are suspended from the main carrier hooks, spaced approximately 2 ft. apart. The entire system is completely continuous and automatic with the exception of the manual loading and unloading of the parts.

During the five spray steps, operating pressures are indicated by gauges on a panel, and alarms operate if pressure drops below the desired amount in any instance. Separate dial thermometers maintain precise control of the temperatures of the spray solutions, supplementing four indicating temperature controllers. For measuring the steam used to produce the solution temperatures, another instrument equipped with an integrator for totalising the flow is employed. Two sets of push buttons provide start and stop control, permitting each pump to be operated individually.

There are five additional instruments in the cabinet where auxiliary equipment is controlled and the production data are recorded. Two temperature controllers automatically control the temperature of the etching process, used to remove surface defects in aluminium parts. The vapour degreasing unit is also controlled from this cabinet.

(*Industrial Finishing, U.S.A., September,* 1952.)

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**Abrasive Belts Speed Tapering of Aircraft Wings**

A large abrasive-belt machine has been adopted for putting the taper and finish on aluminium plate for aircraft wings, and has resulted in high-speed production with low operating costs and initial investment. A standard Hill-Acme (The Hill-Acme Co., Cleveland, Ohio) stainless steel sheet grinding machine was reconverted for this work by the Coated Products Division of the Carborundum Co., Niagara Falls, New York, in conjunction with the Bell Aircraft Corpn., Buffalo, New York, and the United States Air Force.

The process uses a wide-belt machine with a rubber-faced, serrated surface, contact roll. A Carborundum Type-61 wheel is used to back up the belt at the point of contact with the the work. Cuts can be made up to 0·01 in. in depth on aluminium sheets 72 in. wide. Rapid stock removal is possible since a large area can be machined at one time. For example, one typical single taper operation takes 15 min. as compared with 2½ hr. on conventional milling equipment. In this case the special machine was powered by a 250 h.p. motor. Roughing and finishing is effected on the same machine in the same set-up, by changing to a finer belt. The change-over takes only about 40 sec. Work-holding is facilitated, and skilled labour is not required.

Any degree of surface finish can be obtained, with accuracy to within 0·005 in., or less. The metallurgical properties of the aluminium are not affected since the working temperature does not exceed 90° F. during the grinding operation, and warpage is eliminated.

(*The Iron Age*, 21*st August*, 1952.)

**Life of Metal Parts Prolonged by "Flame" Plating with Tungsten Carbide**

Most metal parts can be protected from excessive wear, abrasion, and frictional action by plating with a thin coat of tungsten carbide. A process developed by the Linde Air Products Co., New York, known as "Flame-Plating" can deposit a coating of tungsten carbide to thickness from 0·0005 in. to 0·020 in.

Temperature of the base metal does not exceed 400° F. during the plating operation, and there is little tendency of the part to warp. Flat surfaces, cylinder, holes, and parts with various shapes and contours can be coated satisfactorily. Surfaces up to 6 in. wide and 40 in. long can be handled, and the coated part can be used either as it is or further finished on a grinding machine. In most applications, parts flame-plated with tungsten carbide have shown wear resistance equal to or greater than sintered tungsten carbide and have been far superior to cast alloys, hard chromium plating, and tool steels. In addition to containing all the desirable properties of sintered tungsten carbide, the parts have a lower modulus of elasticity and greater resistance to impact and thermal shock. A wide selection of base metals offers numerous design possibilities.

The tungsten carbide applied by the process differs from sintered tungsten carbide. The elements tungsten, carbon, and 8 per cent. cobalt are present in various compositions. There is no free cobalt. The particles forming the coating are elongated and flattened into discs, the diameter of each particle being several times its thickness. There is an interlocking mechanical bond (not a welded bond) between the coating and the base metal. The coating does not mix with or dilute the base metal, and no visible oxide layer appears. If the base metal is deformed in any way, the coating will crack or separate, depending on its thickness; the thinner the coating the less the tendency it has towards separation.

Finish grinding a coated part will produce a surface of 2 micro-in. r.m.s. Resinoid bonded diamond wheels are used for finish grinding, a 100-mesh wheel being employed for rough grinding and a 400 mesh wheel for finishing, when no more than 0·0005 in. is to be removed. The part is flooded with coolant. Cost of a flame-plated part ranges between the cost of a hard-faced part and a sintered carbide part. Extensive wear tests on fourteen different materials over a two-year period have had interesting results. In one case, a flame-plated gauge outwore all other materials, and the process has proved so successful that other parts such as

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valve plugs, seating rings, balls, mill hammers, cut-off dies, and punches, are now being tested for flame-coating. (*Journal of Metals, October,* 1952.)

**Roller Coating Machine Cuts Costs in Leather Processing**

Through the use of a new roll processing machine designed by the L. R. Wallace Co., Los Angeles, California, to apply treatment solutions to leather materials, leather processors can reportedly conserve processing solutions, promote uniformly treated products, minimise processing variations, and cut production costs by approximately 50 per cent. Where it has been necessary to coat textiles with pyroxgline (or cellulose nitrate lacquers) in the production of artificial leathers, as many as 850 sq. ft. of fabrics have been covered with a single gallon of coating solution, and more than 15,000 sq. ft. of finished materials have been turned out hourly with a single roller unit. Similarly, where Syntans have been used as levelling agents in colouring chrome-tanned hides with water-soluble acid or direct dyes, up to 16,500 sq. ft. of leather have been processed hourly in approximately 15 sq. ft. of plant space.

The roller unit has been found usable with virtually all types of processing fluids (from room temperature up to 300° F.), including acrylic resins, adhesives, wax-base lubricants or preservatives, dyes, inks sizing, and plasting finishing compounds and photo-sensitive emulsions. The unit comprises two neoprene covered steel coating rollers, horizontally aligned, and smaller so-called "doctor" rollers designed to aid retention of processing solutions—all mounted on a portable steel frame. The rolls are driven by a ¼ h.p. motor. While standard coating roll lengths range from approximately 20 in. to 52 in., longer or shorter roll specifications can be provided.

In operation, leathers to be coated are fed into the roller units either manually or automatically, the coating rolls being adjusted to the thickness of the material to be processed, and rotated so that the solutions are transferred to the material as they pass between the rollers.

(*Leather and Shoes,* 13*th September,* 1952.)

## NICKEL BAN EASEMENT

The Board of Trade and the Ministry of Supply announce that as from 26th February the following article may be nickel plated: safety pins, hat pins, loose leaf and filing device fittings, some parts of propelling pencils and ball point pens, spoke nipples, hospital equipment such as cabinets for instruments, tables and operating tables, camera and ticket issuing machines, also many motor car parts and accessories (a complete list is given in the ammended order).

The restrictions still apply to bicycle components, domestic appliances, boat and railway equipment and fittings and radio parts as detailed in the original order.

Copies of the ammended order may be obtained from the Board of Trade and Ministry of Supply.

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## O.C.C.A. EXHIBITION, 1953

The Oil and Colour Chemists' Association announce that they will be holding their fifth technical trade exhibition at Borough Polytechnic, Borough Road, London, S.E.1, on 30th-31st March and 1st April, three halls, The Edric Hall, The Stanley Hall and the Victoria Hall will again be used and the Official Luncheon will be held at the Criterion Restaurant, Piccadilly Circus, London, W.1., on Monday, 30th March, 1953 at 12.30 for 1.00 p.m. As before tickets will be restricted to two per Exhibitor and to members of the Oil & Colour Chemists' Association.

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**Teleflex Products Ltd.**—announce that they have two newly published brochures available. One of these booklets deals with the Teleflex 705 in. Overhead Cable Conveyor and the other with Teleflex Industrial Remote Control Equipment. Copies can be obtained direct from the company at Teleflex Works, Chadwell Heath, Essex.

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# How to Choose, Measure, Specify and Control Colour

## *Some Practical Notes on the Principles of Colour Applications in Industry*

LOOK steadily at the green elephant on the left and, after about 40 sec. switch your eyes to the white one on the right; you should then see something which may or may not be familiar to you, viz., a pink elephant. The colour of this second pachyderm is due entirely to the phenomenon of "after image," he is pink because pink is the complementary colour to green; if the left-hand elephant had been orange then the right hand vision would have been blue.

It is not our intention to suggest that the serious minded technician makes a study of pink elephants; we would, however, suggest that there is considerable profit to be gained from a study of colour techniques. The growing importance of colour as a means of increasing the sales appeal of a product becomes apparent when we consider the increasing use being made of colour in films, advertisements, exhibition display stands and even in office machinery.

Colour, although we may not be aware of it, plays a very important part in deciding our choice between one product and another. This fact must be borne in mind when choosing colour schemes for consumer goods and particularly for export products. The whole field of colour selection involves not only the science of psychology, but often factual relationships embracing the sciences of physics, chemistry, psychophysics and philosophy. For psychological reasons for example; the familiar case of red being used to indicate high temperature or danger can be traced to the fact that man has always associated red with heat and action in thought and emotions. For factual reasons a yellow background is often used to make a dark thread show up in textile machinery. The eye sees more readily when yellow and black are set off against each other than when any other colour combination is used.

Turning from these considerations to the case of colour harmony and its associations we would quote a typical case from the records of an American railway company which demonstrates the care necessary in colour planning, and the difficulties encountered when colour harmony alone is made the basis for choice without further consideration of the practical aspects of the individual case.

This railway company decided to

paint its locomotives in colour to make them attractive and to enhance their prestige value. The first colour scheme chosen was yellow and green. This combination was both attractive and striking but it blended in so well with the Northern Californian foliage that the locos were almost invisible at about two hundred yards. A change followed to black and silver, this was thought to be fairly safe and, again, quite attractive and distinctive, but this time the colours blended in with the silver grey of the desert country of Utah and Nevada and once again the locos could not be seen at quite close range. A final change to orange and black satisfied both æsthetic and practical considerations.

A few more examples will, perhaps, bring the point home even more forcibly. The Dunlop Rubber Co. states that the buying public has always been very sensitive to the colour of rubber used in cycle inner tubes and they say that increases and decreases in sales turnover can be traced to an alteration in the red shade of a popular line. Another example from the same source is the common golf ball. A blue-white colour is best from the sales point of view and any tendency for this colour to change to cream or even plain white during storage, arouses a distinct sales resistance. Physiologically pink would be the best colour from the point of view of making the ball easier for the golfer to hit but no maker so far has had the courage to market such a ball.

Racial characteristics also affect the likes and dislikes of certain people. A survey made a few years ago in the U.S.A. showed that families of Italian extraction favoured mother of pearl, tan and blue-green as colours for refrigerators. White, the "sanitary" colour was chosen by all other groups.

On the other hand white is the Chinese colour for mourning and the writer can recall the case of a firm who could not understand why white enamel goods, acknowledged by most European buyers to be better than their competitor's did not sell so well in China. The answer was that the competitor was one jump ahead of them in the matter of colour as his products were finished in blue.

This matter of colour is most important in the export market as local colour prejudices render certain colours undesirable because of religious beliefs, national sentiment or established custom. Again, this matter must not be dismissed as of no interest to the manufacturer who does not export. Would you, for example, as a home buyer, purchase a primrose yellow motor-car, a pure white radio cabinet or a bedroom suite finished in a bright shade of orange with purple relief?

All the above are rather obvious or specialised examples of the use of appropriate colours. What, we may ask, is the significance of colour when dealing with a technical product such as a rubber-bonded engine mounting? Is colour of any importance in that case? Apparently it is. A technical paper, read before the Institute of the Rubber Industry by a Mr. T. Gray, some years ago answers the point quite well. The author refers to an engineer who may be called on to choose between rubber mountings "which look like a block of rubber covered with a fine vintage bloom, attached to metal parts tastefully finished in a mottle of brass plating, rust and black enamel" and a product cleanly coloured to suggest it is a thing of precision. The choice (apart from any pronounced technical differences, and perhaps in spite of them) would be obvious.

Further examples of the significance of colour are to be found in the present practice of using colours on machines to ensure safety in operation. Warm colours, those with red and yellow in them to indicate cutting edges, moving arms, switchgear, gear-cases, etc. Cool colours, those containing blue, providing the background colour. The physical sense is brought into play in this case as the warm colours will always appear to be advancing and, at a distance of about 20 ft. the warm colour will appear to be about a foot nearer than the cool colour.

A big advance has recently been made by the adoption of colour in office machines and equipment. The high contrast between white paper and dark backgrounds of typewriters, duplicators, desks and other items has, in the past, led to fatigue and has been proved to actually slow down the reaction of the office worker. By introducing lighter colours, for

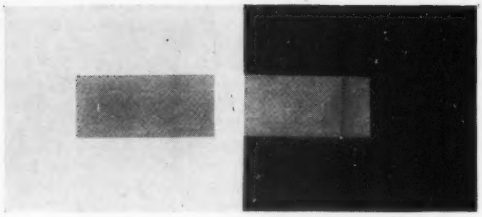

*Diagram to prove that you cannot trust your eyes on colour and shade. The two grey rectangles are both the same shade, as will be seen by masking out the rest of the diagram*

example colours of 35 per cent. light reflectance in place of the older level of about 10 to 15 per cent., there is less eyestrain, less fatigue and, therefore, faster and more accurate work.

Having now emphasised the importance of colour, let us now analyse colour itself. What is colour? What makes colour? What method can be used to specify colour? If we are to use any property for our own ends, the obvious first step is to thoroughly understand the medium in which we are working.

No two people see in the same way the colours which the human eye can discern; incidentally there are about ten million colours distinguishable to the eye. The average man can comfortably distinguish about ninety-five colour family variations but he cannot use with certainty more than about two dozen colour names. We must face the fact that we neither know what colour is nor how we see it. We cannot always tell the name of the colour or its component colour.

In terms of physics the sense of colour is caused by the effect of light waves of different wave lengths striking upon the retina of the eye. Each colour represents a different wave length ranging from 350 to 700 millimicrons (a millimicron is equal to one ten-millionth of a metre). Red colours are from 610 to 700 millimicrons and have the longest wave length, anything less than 350 millimicrons is absorbed in the pupil of the eye before reaching the retina.

When white light or sunlight strikes an object all the visible wave lengths of the spectrum are not reflected back, some are absorbed and the remainder, reflected back to the eye, cause the sensation of colour. Red surfaces, for example a pillar box, absorb all wave lengths except some in the red range. Black surfaces absorb all the visible light wave lengths.

It is true, of course, that most of the world's great painters have neither known nor cared about light wavelengths, the solar spectrum, and so on, but no old master ever had to produce one million articles, of a colour designed to meet competition, and of such uniformity that the first article was completely indistinguishable from the last.

It is just this latter requirement that makes it so necessary for us to be able to describe, designate and specify colours for industrial applications with the certainty that the specification can be understood and adhered to by the average firm turning out large quantities of coloured products.

Obviously it would be physically impossible to use descriptive terms for the purpose of designating the almost innumerable colour variations that exist, consequently there have been many attempts to construct a system of specifying colours, these fall into one or other of the following groups:

(a) *The Arbitrary name system.* This was the first and oldest system and suffers from the big drawback that a term such as "crushed strawberry" or "dusty pink" does not convey the same thing to any two people.

(b) *The code or number systems,* examples of which are the Munsell and Ostwald and the Ridgeway Colour Chart systems. These suffer from four drawbacks as follows: (1) The samples fade and are thus not reliable. (2) It is impossible to include more than a selection of the many hundreds of colours distinguishable to the eye. (3) The presence of surrounding colours can influence the appear-

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ance to the eye of the test colours. (4) The colours of a given code look different under artificial light or natural light.

(c) *Actual physical measurement by means of instruments.* This last system is obviously the most satisfactory. Heretofore, however, the equipment has been relatively expensive and elaborate. During the last few years the advent of the simple and reliable type of instrument known as the reflectometer, has enabled a method to be applied for checking, comparing and specifying colour by a simple set of numbers. The reflectometer is at least equal to the human eye in its power of discrimination and has the advantage that it is not affected by physical or psychological influences. The system is based on the fact that white light consists of equal parts of red, green and blue and it works as follows:

The formula for white light can be written as:

| | |
|---|---|
| Red light ... | 33⅓% |
| Green light ... | 33⅓% |
| Blue light ... | 33⅓% |
| Total White | 100% |

This is the amount of light that a standard white surface would reflect.

When measuring a colour the reflectometer will enable us to compare the amount actually reflected with the amount known to be reflected from white. If we assume that the colour reflects 60 per cent. as much as a standard white surface this can be used as a measure of intensity. The instrument can also tell us that of this 60 per cent. of reflected light, 25 per cent. is red, 15 per cent. green and 20 per cent. blue for example. Having this information we can now express the colour in the style of a formula without risk of error or ambiguity thus:

| | | |
|---|---|---|
| Red ... | ... | 25% |
| Green ... | ... | 15% |
| Blue ... | ... | 20% |
| Total | | 60% = light lavender or pale purple |

The formula will be a little easier to appreciate if, to demonstrate the point, we take away the equal amounts that go to make white. Thus if we take 15 per cent. from each, we get:

| | | |
|---|---|---|
| Red ... | ... | 10% |
| Blue ... | ... | 5% |
| White 3 × 15% | | 45% |
| | | 60% |

It is somewhat easier to see, in this manner, that the colour is a light purple shade. The reflectometer thus provides a means of specifying colour by a formula which tells us its hue, tint and intensity. This is accurate enough for the purposes of colour control and selection.

The use of the reflectometer is becoming essential in factories which make a large range of products all of which must match each other, for instance a range of kitchen equipment which is bought or collected together over a period of time. Seldom will refrigerators, sink units, washing machines, kitchen cabinets and hollow-ware all be made in the same factory, but they will come together in the kitchen and that is where the difference in shade will show up.

The problem of getting a good colour match in cases like this is a serious one. Some kitchen appliances are finished in vitreous enamel, some in organic finishes and some with combinations of both (refrigerators are a typical example of the latter case). Since vitreous enamel is less flexible in its colour range, the normal practice is to prepare colour samples or reference panels of the vitreous shades and use these as reference standards for the matching of the organic finishes.

When a factory is making a continuous run on any product such as, for example, a series of motor-car bodies or wings which will meet up at a later date with other parts, a gradual but none the less definite drift of colour will occur between the start and finish of the run without the human eye being aware of it until the assembly department discovers the difference on the final assembly line—too late to do anything about it.

The human eye is a most unreliable instrument for the purpose of estimat-

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ing colour changes from inspections made at random. It is very much affected by differences between one man and the next, by the health of the viewer, by the influence of surrounding colours, and in any case by the lack of a precise method of specifying a colour in words. However, a regular check by means of the reflectometer can detect changes in good time and, even more important, it can tell just where the colour is wrong. That is to say, it can indicate that a colour which should have 20 per cent. blue in it has only 15 per cent., and suitable steps can be taken to remedy the deficiency.

So far we have dealt with the use, measurement, specification and control of colour; let us, in closing, briefly consider the principles of planning colour applications. The initial step in all colour application plans is to consider the colours in terms of their family group. This method of breakdown is based roughly on the range of colours in the visible spectrum and the colour families are the groups in the successive segments of the visible spectrum as established by a series of vertical lines. With these groups in mind, plus a sound knowledge of the principles of complementary colour and "after image" as evidenced by our pink elephant mentioned in the opening paragraph, such disasters as alternate stripes of red and green creating a visual blur can be avoided. As a further precaution, when planning colours, the following ten questions should be considered:

1. What is the purpose of the colour plan?
2. Under what conditions will the product be used?
3. Where, on the product, will the colour be applied?
4. If for export, what are the religious or political implications?
5. Is there any psychological implication in the product or its uses?
6. What colour does the competitor (if any) employ?
7. Is the product viewed under artificial or natural light? This affects the light under which the choice must be made.
8. What is the life of the product? It is wasteful to use too good a finish on a short life product.
9. Has the material of which the product is made, any natural colour? If so can it be adapted.
10. Is a glossy colour desirable or otherwise.

Colour planning abounds in traps for the unwary and careful checking of the above points, together with a consideration of the examples given earlier, will go far to ease the path of the would-be colour planner. There is, however, no substitute for taste and the judgment that comes from experience.

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**Griffin and Tatlock Ltd.** have recently issued a catalogue of Chemicals and Reagents which will, perhaps, be of interest to readers.

This edition has been set in double column form for ease of reference and, but for a few exceptions, they have adopted the metric system throughout, in accordance with current trends in the laboratory chemicals industry in this country and for the convenience of customers abroad. Copies of this catalogue No. 66 C.R., are available free on request for use in laboratories engaged in research analysis, education and industry.

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**New Telephone No.** Silver Paint and Lacquer Co. Ltd., have had their number changed. It is now Leeds 34641/2.

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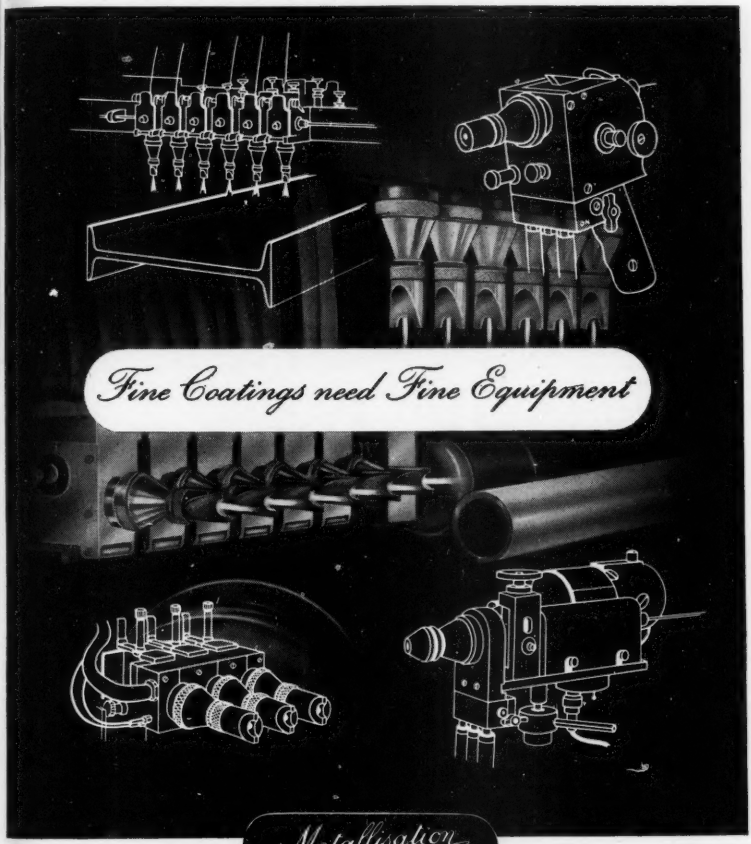


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# NAMES IN THE NEWS

**Retirements**

**Mr. G. R. Salmon** retired from Goodlass Wall and Co. Ltd., on February 28th last after a service life with the company of more than fifty years. He joined the company as junior clerk in 1901 and reached the position of advertising manager via the sales department.

Three employees of Halex Ltd., who together have worked with the Xylonite Group for a combined total of 132 years, retired at the end of 1952.

**Sydney W. Snell,** Halex technical director since 1947, is retiring, but the company retains his services as consultant. Mr. Snell has been responsible for the adoption in the factory of many new production methods.

**Reuben Marshall Greenstock,** a Halex departmental manager, has been behind the introduction of many factory amenities, including social and sports events, during his long service with the company.

**Leonard Wilkinson** joined the organisation at the age of 17, has worked in the Industrial Division of Halex for the past two years. He was previously in charge of sales in the Midlands.

**Appointments and Changes**

**Mr. Reginald G. Sheldrake** has been appointed General Sales Manager of the County Chemical Co. Ltd., Birmingham, the manufacturers of Chemico Cleanser. Prior to the war he was the firm's representative in the London Area.

**John Hand, B.Sc.,** has been made technical director of Scott Bader and Co. Ltd., synthetic resin manufacturers, of Wellingborough, Northants.

Mr. Hand is well known in the paint, rubber and printing-ink trades.

**Mr. G. C. Ivess,** who was managing director of Fleetwood Paints Ltd., resigned recently. We understand, however, that he is not leaving the paint trade.

He was one of the band who fought against the proposed concentration of the paint trade during the war, which resulted in the formation of the P.M.A.T.A. Later he took an active part in Paint Federation affairs and for two years was chairman of the London Association.

**Obituary**

We regret to announce the death of **Mr. F. C. Dyche-Teague,** managing director of Detel Products Ltd., also the death of **Mr. G. C. Bassett,** a past director of Manders Printing Inks Ltd., who was a well-known figure in Midland printing-ink circles.

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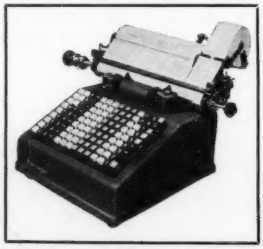

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# ADVERTISERS' INDEX


Aeraspray Manufacturing Co. Ltd., The .. —
Aerograph Co. Ltd., The .. .. .. 530
Air Industrial Developments Ltd. .. .. 579
Allied Paints and Chemicals Ltd. .. .. —
Ashton and Moore (Metal Colourers) Ltd. —
Atlas Diesel Co. Ltd. .. .. .. .. —
Atlas Plating Works Ltd. .. .. .. 599
Ault and Wiborg Group .. .. .. 542

Ballard, F. J. and Co. Ltd. .. .. .. —
Bennett (Hyde) and Co. Ltd. .. .. —
Berger, Lewis (Great Britain) Ltd. .. 540
B.H. Chemicals Ltd. .. .. .. .. 535
Bratt Colbran Ltd. .. .. .. .. —
British Oxygen Co. Ltd. .. .. .. —
British Paints Ltd. .. .. .. .. —
British Vapour Blast Ltd. .. .. .. —
Brough, E. A. and Co. Ltd. .. .. .. 534
Bullows, A. and Sons Ltd... .. *Cover* iv

Canning, W. and Co. Ltd. .. .. .. 531
Carrier Engineering Co. Ltd. .. *Cover* ii
Cellon Ltd. .. .. .. .. .. 529
Controlled Heat and Air Ltd. .. .. —
Croda Ltd. .. .. .. .. .. —
Cruickshank, R. Ltd. .. .. .. .. 591

De La Rue, Thomas and Co. Ltd. .. —
Delta Technical and Commercial Services —
Drummond Patents (Holdings) Ltd. .. 585

Electric Construction Co. Ltd., The .. 573
Electro-Chemical Engineering Co. Ltd., The 539

Fletcher Miller Ltd. .. .. .. .. 538

Gas Council, The .. .. .. .. 526
General Electric Co. Ltd., The .. .. —
General and Industrial Paints Ltd. .. 587
Gittings and Hills Ltd. .. .. .. —
Goldsworthy, Thomas and Sons Ltd. .. —
Goodlass, Wall and Co. Ltd. .. .. 593
Grauer and Weil Ltd. .. .. .. 600
Griffiths, A. E. (Smethwick) Ltd. .. .. 541

Hall, John and Sons (Bristol and London) Ltd. .. .. .. .. .. .. 559
Hawley, John and Co. (Walsall) Ltd. .. —
Heat and Air Systems Ltd. .. .. .. —
Hockley Chemical Co. Ltd., The .. .. —
Holden, Arthur and Sons Ltd. .. .. 533
Honeywell-Brown Ltd. .. .. .. —

Imperial Chemical Industries Ltd. (Paints Division) .. .. .. .. .. —
Incandescent Heat Co. Ltd. .. .. .. —
Ingham Clark, Robert and Co. .. .. —
Ionic Plating Co. Ltd. .. .. .. —

Jenolite Ltd. .. .. .. .. .. 598
Jenson and Nicholson Ltd. .. .. .. 555

Kaylee Transfers Ltd. .. .. .. .. 536
Kearsley, Robert and Co. .. .. .. 536

Learner, A. and Co. Ltd. .. .. .. 593

McDowell, Thomas and Co. Ltd. .. .. —
Macpherson, Donald and Co. Ltd. .. .. 583
Mander Bros. Ltd. .. .. .. .. 597
Metallisation Ltd. .. .. .. .. 595
Metal Porcelains Ltd. .. .. .. .. —
Metropolitan-Vikcers Electrical Co. Ltd... —
Micafine Ltd. .. .. .. .. .. 569
Midland Galvanizers Ltd. .. .. .. —
Minnesota Mining and Manufacturing Co. Ltd. .. .. .. .. .. .. —
Modern Industrial Ventilation and Oven Co. Ltd. .. .. .. .. .. —
Morris, B. O. Ltd. .. .. .. .. *Cover* i

Neil and Spencer Ltd. .. .. .. .. 534
Norgren, C. A. Ltd. .. .. .. .. —

Parkinson and Cowan (Gas Meters) Ltd. 583
Parsons, Thomas and Sons Ltd. .. .. 538
Perfectair Ltd. .. .. .. .. .. —
Pincin, Johnson and Associates Ltd. .. 525
Postans Ltd. .. .. .. .. .. —
Preston, John and Co. Ltd. .. .. —
Prodorite Ltd. .. .. .. .. *Cover* iii
Pyrene Co. Ltd., The .. .. .. .. 544

Radiant Heating Ltd. .. .. .. .. 527

Scrib Ltd. (Metal Section) .. .. .. 565
Shell Chemicals Ltd. .. .. .. .. 537
Spencer and Halstead Ltd. .. .. .. —
Stordy Engineering Ltd. .. .. .. 528
Sunbeam Anti-Corrosives Ltd. .. .. —

Tack All Tackrag (Eng.) Ltd. .. .. —
Technical Brushes Ltd. .. .. .. —
Teleflex Products Ltd. .. .. .. 532
Thornley and Knight Ltd. .. .. .. 551
Titanine Ltd. .. .. .. .. .. —
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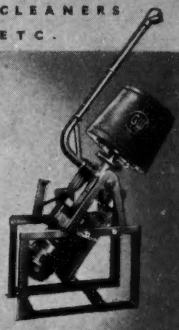

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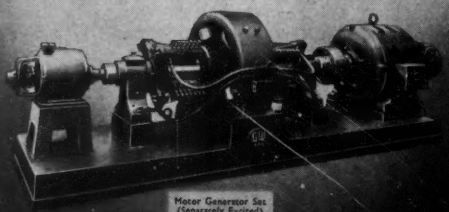

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